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1988-90 Graduate Degree Programs Bulletin

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1988-90 Graduate Degree Programs Bulletin

Graduate Calendar 10

General Information 16

Tuition, Charges, and Student Aid 28

Application and Admission Procedures 34

Procedures and Regulations 38

Graduate Degree Requirements 46

Graduate Programs, Faculty, and Courses 60

Index of Faculty 422

Index of Subjects 433

Address General Inquiries Regarding the Graduate School to:
Graduate School Information Center
113 Kern Graduate Building
The Pennsylvania State University
University Park, PA 16802
Telephone: Area Code 814-865-1878

Directory Assistance for University Telephone Numbers:
814-865-4700

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The educational process necessitates change. This bulletin must be considered as informational and not binding on the University.

Each step of the educational process, from admission through graduation, requires continuing review and appropriate approval by University officials. The University, therefore, reserves the right to change the requirements and regulations contained in this bulletin and to determine whether a student has satisfactorily met its requirements for admission or graduation, and to reject any applicant for admission for any reason the University determines to be material to the applicant's qualification to pursue higher education. Nothing in this bulletin should be considered a guarantee that completion of a program and graduation from the University will result in employment.

THE PENNSYLVANIA STATE UNIVERSITY BULLETIN (USPS 426-680)

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The Graduate School
114 Kern Graduate Building
The Pennsylvania State University
University Park, PA 16802
Telephone: Area Code 814-865-2516

HOWARD B. PALMER, *Senior Associate Dean of the Graduate School*
The Graduate School
114 Kern Graduate Building
The Pennsylvania State University
University Park, PA 16802
Telephone: Area Code 814-865-2516

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JOHN M. LILLEY, *Provost and Dean of Penn State Erie, The Behrend College*
Penn State Erie, The Behrend College
Office of the Dean
Station Road
Erie, PA 16563
Telephone: Area Code 814-898-1511

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LAWRENCE S. COTE, *Center Executive Officer, Penn State Great Valley*
Penn State Great Valley
Office of the Center Executive Officer
30 East Swedesford Road
Malvern, PA 19355
Telephone: Area Code 215-889-1300

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Penn State Harrisburg, The Capital College
Office of the Dean
Route 230
Middletown, PA 17057
Telephone: Area Code 717-948-6100

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C. MCCOLLISTER EVARTS, *Provost and Dean of the College of Medicine*
The Milton S. Hershey Medical Center
Office of the Dean
500 University Drive
Hershey, PA 17033
Telephone: Area Code 717-534-8521

CONTENTS

DIRECTORY OF GRADUATE PROGRAMS AND DEGREES CONFERRED 6
THE GRADUATE COUNCIL 8
THE GRADUATE SCHOOL ADMINISTRATIVE OFFICERS 9
GRADUATE CALENDAR 10
GENERAL INFORMATION
- The Graduate School 16
- Research 18
- Graduate Life 23
- Student Services 25
- Tuition and Charges 28
- Student Aid 30
- Application and Admission Procedures 34
- Procedures and Regulations for Students Enrolled in the Graduate School 38
- Graduate Degree Requirements 46

GRADUATE PROGRAMS, FACULTY, AND COURSES 60
OTHER COURSES AND OPTIONS CARRYING GRADUATE CREDIT 410
OTHER MEMBERS OF THE GRADUATE FACULTY 420
INDEX OF GRADUATE FACULTY MEMBERS 422
INDEX OF SUBJECTS 433

DIRECTORY OF GRADUATE PROGRAMS AND DEGREES CONFERRED

The following degrees are the ones normally conferred in each of the designated major programs. Additional professional degrees, including the M.Agr., M.Ed., and M.Eng., have been authorized in many cases and may be offered at the discretion of the department head or program chair and the dean of the Graduate School. Page references below are to the pages in the 1988-1990 *Graduate Bulletin* where the individual program, including faculty, specific admission and degree requirements, and course offerings, is described. Unless otherwise noted, programs are located at University Park.

*Acoustics — Ph.D., M.S., M.Eng. **60**
Administration of Justice — Ph.D., M.A. **62**
Adult Education (U.P., Capital) — D.Ed., M.Ed. **64**
Adult Education (Behrend) — M.Ed. **64**
Aerospace Engineering — Ph.D., M.S. **66**
Agricultural Economics — Ph.D., M.S., M.Agr. **69**
Agricultural Education — Ph.D., D.Ed., M.S., M.Ed. **72**
Agricultural Engineering — Ph.D., M.S. **74**
Agricultural Mechanization — M.Agr. **77**
Agronomy — Ph.D., M.S., M.Agr. **78**
American Studies (Capital) — M.A. **81**
Anatomy (Hershey) — Ph.D., M.S. **83**
Animal Science — Ph.D., M.S., M.Agr. **85**
Anthropology — Ph.D., M.A. **87**
Architectural Engineering — M.S. **89**
Architecture — M.S. **91**
Art — M.A., M.F.A. **93**
Art Education — Ph.D., D.Ed., M.S., M.Ed. **94**
Art History — Ph.D., M.A. **96**
Astronomy — Ph.D., M.S. **98**
Biochemistry — Ph.D., M.S. **101**
*Bioengineering (U.P., Hershey — Ph.D., M.S. **103**
Biological Chemistry (Hershey) — Ph.D., M.S. **105**
Biology — Ph.D., M.S. **106**
Botany — Ph.D., M.S. **110**
Business Administration (U.P.) — Ph.D., M.S., M.B.A. **111**
Business Administration (Behrend) — M.B.A. **122**
Business Administration (Capital) — M.B.A. **126**
Business Administration/French Studies — M.S./M.A., M.B.A./M.A. **222**
Cell and Molecular Biology (Hershey) — Ph.D., M.S. **131**
Ceramic Science — Ph.D., M.S. **133**
Chemical Engineering — Ph.D., M.S. **135**
Chemistry — Ph.D., M.S. **137**
Civil Engineering — Ph.D., M.S., M.Eng. **140**
Communication Disorders — Ph.D., M.S., M.Ed. **144**
Community Systems Planning and Development — Ph.D., M.S. **148**
Comparative Literature — Ph.D., M.A. **151**
Computer Engineering — Ph.D., M.S. **154**
Computer Science — Ph.D., M.S. **156**
Counseling Psychology — Ph.D. **160**
Counselor Education — D.Ed., M.S., M.Ed. **161**
Curriculum and Instruction — Ph.D., D.Ed., M.S., M.Ed. **164**
Curriculum and Instruction (Great Valley) — M.S., M.Ed. **164**
*†Demography — Ph.D., M.S. **170**
Developmental and Remedial Reading — M.Ed. **172**
Earth Sciences — D.Ed., M.Ed. **173**
*Ecology — Ph.D., M.S. **174**
Economics — Ph.D., M.A. **176**
Educational Administration — Ph.D., D.Ed., M.S., M.Ed. **179**
Educational Psychology — Ph.D., M.S. **182**
Educational Theory and Policy — Ph.D., M.A. **185**
Electrical Engineering — Ph.D., M.S. **187**
Engineering Mechanics — M.S., M.Eng. **192**
Engineering Science — M.S. **195**
Engineering Science (Behrend, Great Valley, Capital) — M.Eng. **197**
English — Ph.D., M.A., M.Ed., M.F.A. **199**
Entomology — Ph.D., M.S., M.Agr. **204**
Environmental Engineering — Ph.D., M.S., M.Eng. **206**
*Environmental Pollution Control (U.P., Capital) — M.S., M.Eng., M.E.P.C. **207**
Exercise and Sport Science — Ph.D., D.Ed., M.S., M.Ed. **209**
Extension Education — M.Agr., M.Ed. **213**
Film and Video — M.A., M.F.A. **214**
Fish and Wildlife Sciences — M.S., M.Agr. **215**
Food Science — Ph.D., M.S. **217**
Forest Resources — Ph.D., M.S., M.Agr., M.F.R. **219**

*Intercollege Graduate Program
‡See Geosciences
†Dual-title Program Option

French — Ph.D., M.A. *(see also* Business Administration/French Studies) **222**
Fuel Science — Ph.D., M.S. **226**
*Genetics (U.P., Hershey) — Ph.D., M.S. **227**
‡Geochemistry and Mineralogy — Ph.D., M.S. **236**
Geography — Ph.D., M.S. **230**
‡Geology — Ph.D., M.S. **239**
‡Geophysics — Ph.D., M.S. **241**
Geosciences — Ph.D., M.S. **233**
German — Ph.D., M.A., M.Ed. **241**
Health Education — Ph.D., D.Ed., M.S., M.Ed. **246**
Health Education (Capital) — M.Ed. **246**
Health Planning and Administration — M.H.A. **248**
Higher Education — Ph.D., D.Ed., M.Ed. **250**
History — Ph.D., D.Ed., M.A., M.Ed. **252**
Home Economics Education — Ph.D., D.Ed., M.S., M.Ed. **256**
Horticulture — Ph.D., M.S., M.Agr. **257**
Human Development and Family Studies — Ph.D., M.S., M.Ed. **260**
Humanities (Capital) — M.A. **263**
Industrial Engineering — Ph.D., M.S., M.Eng. (Great Valley, M.Eng.) **266**
Laboratory Animal Medicine (Hershey) — M.S. **270**
Landscape Architecture — M.L.A. **271**
Linguistics — M.A. **273**
Management (Great Valley) — M. Mgmt. **275**
Man-Environment Relations — Ph.D., D.Ed., M.S., M.Ed. **276**
Mass Communications — Ph.D.*, M.A. **278**
Mathematics — Ph.D., D.Ed., M.A., M.Ed. **282**
Mathematics (Great Valley) — M.Ed. **282**
Mechanical Engineering — Ph.D., M.S., M.Eng. **288**
Metals Science and Engineering — Ph.D., M.S. **292**
Meteorology — Ph.D., M.S. **295**
Microbiology — Ph.D., M.S. **298**
Microbiology (Hershey) — Ph.D., M.S. **300**
Mineral Economics — Ph.D., M.S. **302**
Mineral Engineering Management — M.Eng. **304**
Mineral Processing — Ph.D., M.S. **305**
Mining Engineering — Ph.D., M.S., M.Eng. **308**
Molecular and Cell Biology — Ph.D., M.S. **311**
Music — D.Ed., M.A., M.Mus., M.Ed. **313**
Neuroscience (Hershey) — Ph.D., M.S. **316**
Nuclear Engineering — Ph.D., M.S., M.Eng. **319**
Nursing — M.S. **321**
*Nutrition — Ph.D., M.S., M.Ed. in Human Nutrition **323**
*†Operations Research — Ph.D., M.S. **326**
Petroleum and Natural Gas Engineering — Ph.D., M.S. **330**
Pharmacology (Hershey) — Ph.D., M.S. **332**
Philosophy — Ph.D., M.A. **334**
Physics — Ph.D., D.Ed., M.S., M.Ed. **337**
*Physiology (U.P., Hershey) — Ph.D., M.S. **340**
Plant Pathology — Ph.D., M.S., M.Agr. **343**
*Plant Physiology — Ph.D., M.S. **346**
*Policy Analysis — M.S. **348**
Political Science (U.P., Capital) — Ph.D., M.A. **350**
Polymer Science — Ph.D., M.S. **353**
Poultry Science — M.S. **356**
Psychology — Ph.D., M.S. **357**
Psychosocial Science (Capital) — M.Ps.Sc. **362**
Public Administration — M.P.A. **365**
Public Administration (Capital) — M.P.A. **368**
Recreation and Parks — Ph.D., M.S., M.Ed. **371**
Recreation and Parks (Capital) — M.Rc.Pk. **373**
Rural Sociology — Ph.D., M.S., M.Agr. **374**
School Psychology — Ph.D., M.S., M.Ed. **376**
Sociology — Ph.D., M.A. **377**
*Solid State Science — Ph.D., M.S. **381**
Spanish — Ph.D., M.A., M.Ed. **383**
Special Education — Ph.D., M.S., M.Ed. **386**
Special Education (Great Valley) — M.Ed. **386**
Speech Communication — Ph.D., M.A. **388**
Statistics — Ph.D., M.S., M.A. **392**
Teaching and Curriculum (Capital) — M.Ed. **396**
Teaching English as a Second Language — M.A. **398**
Theatre Arts — M.A., M.F.A. **399**
Training and Development (Capital) — M.Ed. **403**
Veterinary Science — Ph.D., M.S. **405**
*Vocational Education — Ph.D., D.Ed. **407**
Vocational Industrial Education — Ph.D., D.Ed., M.S., M.Ed. **408**
Wildlife Management — See Fish and Wildlife Sciences

*Intercollege Graduate Program
‡See Geosciences
†Dual-title Program Option

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*Term of office expires 1988
**Term of office expires 1989
†Ex officio

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GRADUATE CALENDAR*

SUMMER SESSION 1988

MAY

9 Monday — Last date for a prospective graduate student to submit completed application materials for admission for the summer session 1988. An international applicant should submit materials at least four months before the beginning of the semester or session for which he or she is applying.

9 Monday — Last date for a graduate student to apply for permission to resume study in the summer session 1988

JUNE

6–7 Monday, Tuesday — Orientation and registration

8 Wednesday — Classes begin

13 Monday— Last date for an August graduate to schedule final oral doctoral examination

16 Thursday — Last date for an August graduate to pay thesis fee at Bursar's Office and to activate intent to graduate in the Registrar's Office

24 Friday — Applications for vacated fall semester 1988 tuition grants-in-aid are due in 319 Kern Graduate Building

27 Monday — Last date for an August graduate to pass final oral doctoral examination

27 Monday — Last date for an August graduate to submit master's thesis to Graduate School Thesis Office

JULY

4 Monday — Independence Day holiday

5 Tuesday — Last date for an August graduate to submit doctoral thesis to Graduate School Thesis Office

5 Tuesday — Last date for departments to certify to Graduate School completion of required papers for August graduates

25 Monday — Last date for a prospective graduate student to submit completed application materials for admission for the fall semester 1988. An international applicant should submit materials at least four months before the beginning of the semester or session for which he or she is applying.

25 Monday — Last date for a graduate student to apply for permission to resume study in the fall semester 1988

AUGUST

3 Wednesday — Classes end

4–6 Thursday – Saturday — Final examinations

13 Saturday — Summer commencement

**This calendar is subject to change without notice.* In preparing the calendar for an academic year, the University makes every effort to avoid conflict with religious holidays. However, such conflicts are sometimes unavoidable. When they occur, efforts are made to make special arrangements for the students affected.

NOTE: Students who plan to take examinations in French, German, and Spanish should apply through the Office of University Testing Services, 23 Willard Building. Times and places of tests will be announced when the application is filed.

FALL SEMESTER 1988

JULY

25 Monday — Last date for a prospective graduate student to submit completed application materials for admission to the fall semester 1988. An international applicant should submit materials at least four months before the beginning of the semester or session for which he or she is applying.

25 Monday — Last date for a graduate student to apply for permission to resume study in the fall semester 1988

AUGUST

22–23 Monday, Tuesday — Orientation and registration

24 Wednesday — Classes begin

SEPTEMBER

5 Monday — Labor Day holiday

13 Tuesday — Last date for a December graduate to pay thesis fee at Bursar's Office and to activate intent to graduate in Registrar's Office

OCTOBER

3 Monday — Last date for a December graduate to schedule final oral doctoral examination

10 Monday — Last date for a December graduate to submit master's thesis to Graduate School Thesis Office

17 Monday — Last date for a December graduate to pass final oral doctoral examination

24 Monday — Last date for a December graduate to submit doctoral thesis to Graduate School Thesis Office

24 Monday — Last date for departments to certify to Graduate School completion of required papers for December graduates

28 Friday — Applications for spring semester 1989 tuition grants-in-aid are due in 319 Kern Graduate Building

NOVEMBER

24–27 Thursday–Sunday — Thanksgiving holiday

DECEMBER

9 Friday — Last date for a prospective graduate student to submit completed application materials for admission to the spring semester 1989. An international applicant should submit materials at least four months before the beginning of the semester or session for which he or she is applying.

9 Friday — Last date for a graduate student to apply for permission to resume study in the spring semester 1989

9 Friday — Classes end

12–17 Monday – Saturday — Final examinations

NOTE: There is no graduate commencement ceremony in the fall semester.

NOTE: Students who plan to take examinations in French, German, and Spanish should apply through the Office of University Testing Services, 23 Willard Building. Times and places of tests will be announced when the application is filed.

SPRING SEMESTER 1989

DECEMBER

9 Friday — Last date for a prospective graduate student to submit completed application materials for admission for the spring semester 1989. An international applicant should submit materials at least four months before the beginning of the semester or session for which he or she is applying.

9 Friday — Last date for a graduate student to apply for permission to resume study in the spring semester 1989

JANUARY

5–6 Thursday, Friday — Orientation and registration

9 Monday — Classes begin

30 Monday — Last date for a May graduate to pay thesis fee at Bursar's Office and to activate intent to graduate in Registrar's Office

FEBRUARY

24 Friday — Last date for a May graduate to schedule final oral doctoral examination

27–Mar 3 Monday–Friday — Spring holiday

MARCH

1 Wednesday — Completed application materials for incoming and continuing graduate students for 1989-90 fellowships awarded by the Graduate School are due in 319 Kern Graduate Building

6 Monday — Last date for a May graduate to submit master's thesis to Graduate School Thesis Office

13 Monday — Last date for a May graduate to pass final oral doctoral examination

20 Monday — Last date for a May graduate to submit doctoral thesis to Graduate School Thesis Office

20 Monday — Last date for departments to certify to Graduate School completion of required papers for May graduates

24 Friday — Applications for summer session 1989 tuition grants-in-aid are due in 319 Kern Graduate Building

APRIL

7 Friday — Graduate School tuition assistance applications for summer session 1989 are due in 319 Kern Graduate Building

28 Friday — Classes end

MAY

1–6 Monday–Saturday — Final examinations

8 Monday — Last date for a prospective graduate student to submit completed application materials for admission for the summer session 1989. An international applicant should submit materials at least four months before the beginning of the semester or session for which he or she is applying

8 Monday — Last date for a graduate student to apply for permission to resume study in the summer session 1989

13 Saturday — Spring commencement

NOTE: Students who plan to take examinations in French, German, and Spanish should apply through the Office of University Testing Services, 23 Willard Building. Times and places of tests will be announced when the application is filed.

SUMMER SESSION 1989

MAY

8 Monday — Last date for a prospective graduate student to submit completed application materials for admission for the summer session 1989. An international applicant should submit materials at least four months before the beginning of the semester or session, for which he or she is applying.

8 Monday — Last date for a graduate student to apply for permission to resume study in the summer session 1989

JUNE

6 Tuesday — Orientation and registration

7 Wednesday — Classes begin

12 Monday — Last date for an August graduate to schedule final oral doctoral examination

19 Monday — Last date for an August graduate to pay thesis fee at Bursar's Office and to activate intent to graduate in the Registrar's Office

23 Friday — Applications for fall semester tuition grants-in-aid are due in 319 Kern Graduate Building

26 Monday — Last date for an August graduate to pass final oral doctoral examination

26 Monday — Last date for an August graduate to submit master's thesis to Graduate School Thesis Office

JULY

3 Monday — Last date for an August graduate to submit doctoral thesis to Graduate School Thesis Office

3 Monday — Last date for departments to certify to Graduate School completion of required papers for August graduates

4 Tuesday — Independence Day holiday

26 Wednesday — Last date for a prospective graduate student to submit completed application materials for admission for the fall semester 1989. An international applicant should submit materials at least four months before the beginning of the semester or session for which he or she is applying.

26 Wednesday — Last date for a graduate student to apply for permission to resume study in the fall semester 1989

AUGUST

2 Wednesday — Classes end

3–5 Thursday – Saturday — Final examinations

12 Saturday — Summer commencement

NOTE: Students who plan to take examinations in French, German, and Spanish should apply through the Office of University Testing Services, 23 Willard Building. Times and places of tests will be announced when the application is filed.

FALL SEMESTER 1989

JULY

26 Wednesday — Last date for a prospective graduate student to submit completed application materials for admission for the fall semester 1989. An international applicant should submit materials at least four months before the beginning of the semester or session for which he or she is applying.

26 Wednesday — Last date for a graduate student to apply for permission to resume study in the fall semester 1989

AUGUST

21–22 Monday, Tuesday — Orientation and registration

23 Wednesday — Classes begin

SEPTEMBER

4 Monday — Labor Day holiday

13 Wednesday — Last date for a December graduate to pay thesis fee at Bursar's Office and to activate intent to graduate in Registrar's Office

OCTOBER

2 Monday — Last date for a December graduate to schedule final oral doctoral examination

9 Monday — Last date for a December graduate to submit master's thesis to Graduate School Thesis Office

16 Monday — Last date for a December graduate to pass final oral doctoral examination

23 Monday — Last date for a December graduate to submit doctoral thesis to Graduate School Thesis Office

23 Monday — Last date for departments to certify to Graduate School completion of required papers for December graduates

27 Friday — Applications for spring semester 1990 tuition grants-in-aid are due in 319 Kern Graduate Building

NOVEMBER

23–26 Thursday–Sunday — Thanksgiving holiday

DECEMBER

8 Friday — Classes end

11 Monday — Last date for a prospective graduate student to submit completed application materials for admission for the spring semester 1990. An international applicant should submit materials at least four months before the beginning of the semester or session for which he or she is applying.

11 Monday — Last date for a graduate student to apply for permission to resume study in the spring semester 1990

11–16 Monday–Saturday — Final examinations

NOTE: Students who plan to take examinations in French, German, and Spanish should apply through the Office of University Testing Services, 23 Willard Building. Times and places of tests will be announced when the application is filed.

NOTE: There is no graduate commencement ceremony in the fall semester.

SPRING SEMESTER 1990

DECEMBER

11 Monday — Last date for a prospective graduate student to submit completed application materials for admission to the spring semester 1990. An international applicant should submit materials at least four months before the beginning of the semester or session for which he or she is applying.

11 Monday — Last date for a graduate student to apply for permission to resume study in the spring semester 1990

JANUARY

4–5 Thursday, Friday — Orientation and registration

8 Monday — Classes begin

29 Monday — Last date for a May graduate to pay thesis fee at Bursar's Office and to activate intent to graduate in Registrar's Office

FEBRUARY

26 Monday — Last date for a May graduate to schedule final oral doctoral examination

26–Mar 2 Monday–Friday — Spring holiday

MARCH

1 Tuesday — Completed application materials for incoming and continuing graduate students for 1990-91 fellowships awarded by the Graduate School are due in 319 Kern Graduate Building

5 Monday — Last date for a May graduate to submit master's thesis to Graduate School Thesis Office

12 Monday — Last date for a May graduate to pass final oral doctoral examination

19 Monday — Last date for a May graduate to submit doctoral thesis to Graduate School Thesis Office

19 Monday — Last date for departments to certify to Graduate School completion of required papers for May graduates

30 Friday — Applications for summer session 1990 tuition grants-in-aid are due in 319 Kern Graduate Building

APRIL

6 Friday — Graduate School tuition assistance applications for summer session 1990 are due in 319 Kern Graduate Building

27 Friday — Classes end

30–May 5 Monday–Saturday — Final examinations

MAY

9 Wednesday — Last date for a prospective graduate student to submit completed application materials for admission for the summer session 1990. An international applicant should submit materials at least four months before the beginning of the semester or session for which he or she is applying.

9 Wednesday — Last date for a graduate student to apply for permission to resume study in the summer session 1990

12 Saturday — Spring commencement

NOTE: Students who plan to take examinations in French, German, and Spanish should apply through the Office of University Testing Services, 23 Willard Building. Times and places of tests will be announced when the application is filed.

GENERAL INFORMATION

THE GRADUATE SCHOOL

HISTORY

Graduate work was first offered at Penn State in 1862. Some years after, a committee of the General Faculty was given the responsibility of establishing standards and regulations governing graduate work and the granting of master's and certain technical degrees. The Graduate School was formally established in 1922 by the President and the Board of Trustees. An administrative staff was organized, and the Graduate Faculty was formed. The University Senate delegated to this faculty responsibility for graduate affairs, subject to review. In 1924, the Board of Trustees authorized the granting of the degree of Doctor of Philosophy, and the first Ph.D. was awarded in 1926. On May 9, 1971, a Graduate Council was established for the Graduate School. Today, graduate study is offered in about 130 major programs, with 18 advanced academic and professional degrees being conferred. During the academic year 1986-87, approximately 8,000 graduate students were enrolled and approximately 1,600 advanced degrees were conferred, of which 350 were doctorates.

The Graduate School is a member of the Association of Graduate Schools (an organization within the Association of American Universities) and of the Council of Graduate Schools in the United States.

THE GRADUATE FACULTY

The major role of the Graduate School is to emphasize those aspects of University activity that pertain directly to major programs in graduate study. Through its Graduate Faculty it represents a large segment of the academic strength of the University and is thus a dominant force in sustaining and furthering the intellectual quality of the entire institution. The departments and colleges of the University formulate study and research programs appropriate to their fields. The Graduate Faculty consists of those members of the college faculties who have authorization through the Graduate School to offer courses and seminars and supervise research and theses consistent with the highest academic standards. Thus, the Graduate School may be regarded as a federation of selected segments of the college faculties.

THE GRADUATE COUNCIL

The governance of the Graduate School is vested in a Graduate Council, whose legislative authority is subject to the specific restrictions of the "Articles of Authority." The council forms its own standing committee structure under bylaws outlined in "Articles of Authority, Standing Rules, and Bylaws of the University Graduate Council."

The Committee on Committees and Procedures recommends appointment of members of all other committees of the council and periodically reviews the committee structure and recommends changes as necessary.

The Executive Committee assists the council chair in setting the agenda for council meetings and provides advice and counsel, as requested, to the dean of the Graduate School.

The Committee on Academic Standards recommends to the council criteria for membership in the Graduate Faculty, standards and policies for the admission of students, and thesis regulations and requirements. The committee also advises the council on problems of graduate training and professional development in the area of language and communication skills.

The Committee on Programs and Courses is responsible to the council for evaluation and review of new and existing graduate courses and programs.

The Committee on Graduate Research informs and advises the council on issues, procedures, and opportunities relating to graduate research and fosters outstanding graduate research through special recognitions and awards.

The Committee on Graduate Student and Faculty Affairs is responsible for the review of new and existing policies concerning the welfare and professional ethics of the Graduate Faculty and graduate students, for the investigation of means to further the cultural, intellectual, and social welfare of the graduate community, and for assisting the council chair in the review of appeals concerning violation of accepted norms of professional behavior of graduate students and faculty.

The Committee on Fellowships and Awards considers awards policies and judges applications for grants-in-aid, scholarships, and Graduate School fellowships.

The Committee on Lecture Series secures speakers and arranges for the Graduate School lecture series.

ADMINISTRATION

Executive and administrative matters of the Graduate School are the responsibility of the dean, who is charged directly with enforcement of the regulations of the Graduate School and with organization of its administrative procedures. The dean has a major responsibility to enhance and ensure the high quality of graduate study and research of graduate students. The dean exercises leadership in initiating new programs and in restructuring or phasing out marginal and obsolete ones and encourages and assists in the development of interdisciplinary programs. The dean is assisted in this work by an administrative and clerical staff.

The main administrative offices of the Graduate School are located at University Park on the first three floors of the Kern Graduate Building, named in honor of the late Dean Emeritus Frank D. Kern, who was the first dean of the Graduate School. There are five major administrative divisions in the Graduate School to which the student may go directly for answers to questions that require administrative assistance or decisions:

1. *Graduate Admissions,* 201 Kern Graduate Building. The Office of Graduate Admissions has responsibility for processing all matters pertaining to a student's admission.
2. *Graduate Student Programs,* 211 Kern Graduate Building. The functions of the Office of Graduate Student Programs encompass responsibilities for the academic involvement and concerns of all graduate students from the time they are admitted until they graduate, such as (a) registration of students, (b) readmission of students, (c) maintenance of records, (d) appointment of graduate committees for doctoral students, (e) scheduling of graduate student comprehensive and final oral examinations, (f) checking for accomplishment by students of Graduate Faculty requirements for all advanced degrees and preparation of official commencement lists, and (g) attention to student academic problems.
3. *Graduate Minority Affairs,* 308 Kern Graduate Building. The Center for Minority Graduate Opportunities provides extensive information, advice, and assistance to prospective and enrolled minority graduate students and coordinates minority graduate recruitment and retention activities in the colleges of the University.
4. *Graduate Fellowships and Awards,* 319 Kern Graduate Building. The Office of Graduate Fellowships and Awards serves as a clearinghouse for information on available fellowships and other awards for graduate students, administers fellowships and other award programs involving students in more than one college, and seeks support for graduate students attending the University.
5. *Theses,* 303 Kern Graduate Building. The Thesis Office is responsible for reviewing all theses to ensure that they meet format requirements consistent with the attainment of high scholarly standards and for providing information on thesis preparation.

PROGRAM LOCATIONS

Programs of graduate study are offered at five locations in Pennsylvania:

Penn State Erie, The Behrend College — Penn State-Behrend (Station Rd., Erie, PA 16563) provides convenient opportunity for graduate education to persons residing in northwestern Pennsylvania. It offers a program leading to the degree of Master of Business Administration and an extended M.Ed. in Adult Education.

Penn State Harrisburg, The Capital College — Penn State Harrisburg (Route 230, Middletown, PA 17057), close to the state capital at Harrisburg, was opened in 1966. Graduate programs leading to the degrees of Master of Arts with majors in American Studies and in Humanities, Master of Business Administration, Master of Education with majors in Teaching and Curriculum and in Training and Development, Master of Engineering with a major in Engineering Science, Master of Environmental Pollution Control, Master of Psychosocial Science, Master of Public Administration, and Master of Recreation and Parks are currently offered. Cooperative programs between Penn State Harrisburg and University Park lead to the Master of Education and Doctor of Education degrees in Adult Education and the Ph.D. in Political Science.

The Milton S. Hershey Medical Center — The University's Medical Center (500 University Dr., Hershey, PA 17033) was established in 1963, and the first class of medical students entered in the fall of 1967. In conjunction with Penn State's Graduate School, the College of Medicine offers programs leading to the Master of Science degree with a major in Laboratory Animal Medicine, and to the Doctor of Philosophy and Master of Science degrees with majors in Anatomy, Biological Chemistry, Cell and Molecular Biology, Microbiology, Neuroscience, Pharmacology, and the intercollege programs in Bioengineering, Genetics, and Physiology.

Penn State Great Valley — Penn State Great Valley (30 East Swedesford Rd., Malvern, PA 19355) offers programs leading to the degrees of Master of Education with majors in Curriculum and Instruction, Mathematics, and Special Education; Master of Engineering with majors in Engineering Science and Industrial Engineering; and Master of Science in Curriculum and Instruction.

University Park — University Park (PA 16802), located in the municipality of State College in central Pennsylvania, is the largest of the Penn State campuses and offers more than 100 programs of graduate study.

RESEARCH

Penn State faculty and their graduate student associates have long been recognized nationally and internationally for their accomplishments in basic and applied research. The construction of the field ion microscope, the development of an efficient process of no-till corn planting, and the creation of crownvetch, now widely used in controlling erosion on highway embankments, are all products of Penn State researchers. These accomplishments have been followed by other contributions, including advances in artificial insemination that have already saved farmers and consumers hundreds of millions of dollars, a surgical technique that dramatically reduces the death rate for infants suffering from a congenital heart defect, and inventions that vastly improve operation and monitoring of heart pacemakers. Research at Penn State, now at the $173 million per year level, has led to specialized products, such as archaeological instructional films illustrated from excavations of a Mayan city, and to products with wide social utility, such as the knowledge, derived from failure tests, that a segmental bridge will carry ten times its design load.

In a typical year, about one-fourth to one-third of the patents pending or issued to University personnel name graduate students as coinventors. As one example, graduate student and faculty researchers at Penn State developed and patented a delayed-action mushroom nutrient, now sold throughout the country, that increases growers' yields by about 40 percent.

Other individual and ongoing research projects culminate in published contributions to the sciences, the humanities, and the arts. In a typical year, Penn State faculty, often with the collaboration of graduate students, produce more than 2,500 books, technical papers, journal articles, stories, musical compositions, recordings, art works, and dramatic productions. *The Shaw Review, JGE: The Journal of General Education, Philosophy and Rhetoric, The Chaucer Review,* and *General Linguistics* are all published by the Penn State Press and edited by scholars who are members of the University's Graduate Faculty.

RESEARCH FACILITIES

Of the University's more than 16,000 acres of land, a substantial portion consists of recreation areas, farms and agricultural experiment grounds, and forest tracts that are used by graduate students in their work and research. Animal and wildlife students, for example, are currently conducting nutrition and physiology studies of whitetail deer and blue duikers, a tiny African antelope, sheltered at one of the forest tracts. Astronomy students study at an observatory housing the largest telescope east of the Rockies. Those in civil engineering can carry out research at the only highway test track in Pennsylvania. Laboratories and equipment devoted to meteorology, mining, chemistry, combustion, biomechanics, engineering acoustics, psychology, and microbiology mirror the University's strengths in those disciplines. Recombinant DNA and microelectronics groups have established themselves here, and centers of expertise in computer-assisted design and manufacture, as well as robotics, have emerged.

In addition to research conducted in academic departments or in organized research units within individual colleges, opportunities for interdisciplinary research exist in seven intercollege research units: the Applied Research Laboratory, the Center for the Study of Higher Education, the Environ-

mental Resources Research Institute, the Institute for Arts and Humanistic Studies, the Materials Research Laboratory, the Pennsylvania Transportation Institute, and the Institute for Policy Research and Evaluation. The Health Physics Office and the Laboratory Animal Resources Program are other intercollege units that provide University-wide services for instruction as well as research opportunities for graduate students.

THE UNIVERSITY LIBRARIES

The University Libraries system includes a central collection, four subject branch libraries, and one reading room at University Park. Libraries are also located at the Milton S. Hershey Medical Center; Penn State Harrisburg, The Capital College; Penn State Great Valley; and Penn State Erie, The Behrend College, and at each of the seventeen two-year campuses.

At University Park, the central collection, the Arts Library, and the Life Sciences Library are all housed in the Fred Lewis Pattee Library. There are four branch libraries serving the Colleges of Earth and Mineral Sciences, Engineering, Science, and the Department of Mathematics; one reading room in the Department of Architecture; and the Pollock Library in an undergraduate dormitory area. Included in the central collection are general reference books and periodicals, works in agriculture, biology, education, psychology, economics and business, the humanities, the natural and social sciences, maps, manuscripts, and government documents.

Among special collections of national importance are those of Joseph Priestley, Arnold Bennett, John O'Hara, Conrad Richter, Vance Packard, Jean Giraudoux, Kenneth Burke, William Scranton, Richard Schweiker, the Allison-Shelley Collection of Anglica-Americana-Germanica, and Australian and Utopian literature. The Rare Books Room is particularly rich in literature but has also substantial rare book holdings in architecture, landscape gardening, and miscellaneous subject areas. The Historical Collections and Labor Archives contain a wide variety of documentary sources, including audio archives, the papers of Pennsylvania leaders and businesses, and records of labor unions, most notably those of the United Steelworkers of America. The Penn State Room and the University Archives house an extensive collection of materials about the University and the local community.

Several courses in library studies are offered each year by library faculty. In addition, a program of library instruction includes sessions provided as a part of regularly scheduled University courses in cooperation with the course instructors and seminars by library faculty. General library orientation tours are offered at the beginning of each semester and summer session.

Computerized literature searches of approximately 200 data bases in the sciences, social sciences, engineering, and the humanities are available mostly on a fee basis through the General Reference Section, the related branch libraries, and libraries at various campuses of the University. Most bases emphasize access to current materials, and many contain information similar to that which appears in printed abstracts and indexes; others, however, have no printed counterpart.

For visually impaired and learning-disabled people, the Kurzweil machine, which converts print to speech, is available for use in Pattee. Other equipment for the handicapped includes closed-circuit TV, which enlarges print onto a video screen, and electronic aids, including calculators with synthesized speech capabilities. The first voice-indexed dictionary in recorded form was added recently. In cooperation with the Faculty Women's Club of State College, the University Libraries also provide tape-recorded text and text-related materials upon request.

Automation is an evolving system at the University Libraries. LIAS, the Library Information Access System, is an on-line electronic catalog replacing the traditional card catalogs that have served Penn State for more than a century. LIAS gives the user direct access to bibliographical information about most of the material in the Libraries from terminals at Pattee and branches at University Park and at Penn State campuses throughout the state. Remote access from other terminals on and off campus is also available via direct-dial service. The quality and size of the LIAS data base is increasing significantly and will eventually represent nearly everything the Libraries own. Introductory sessions are offered on a regular basis to familiarize faculty, students, and other library users with the LIAS system. A microcomputer facility located in West Pattee provides students, faculty, and staff with an opportunity to use microcomputers and standard software packages.

The University Libraries are a member of numerous consortia. The Libraries are one of the four Regional Library Resource Centers established by Pennsylvania law and are also members of the Association of Research Libraries, the Research Libraries Group, Inc., and the Pittsburgh Regional Libraries Center. One of the many benefits derived from these affiliations is the sharing of resources through interlibrary loan service. This supplemental service assists researchers in gaining access to materials not otherwise available at the University Libraries. The University Libraries also borrow from many other libraries as well.

The Libraries have approximately 2,800,000 cataloged volumes; 1,300,000 government documents; 29,000 serials; 340,000 maps; 2,000,000 microforms; 18,000 music cassettes and records; and more than 2,000,000 other bibliographical items. Among the publications issued by the Libraries are titles in the University Libraries Bibliographical Series of which *Utopian Literature in the Pennsylvania State University Libraries* is a recent addition. *Penn State Libraries: A User's Guide* is a useful tool that is available at public service desks throughout the University Libraries system. In addition to these publications, many informational leaflets and brochures are also available.

THE PENN STATE PRESS

The Penn State Press is a publisher of scholarly books and several journals for the advancement of scholarship. It publishes in most areas of academic concern including art and architectural history, literature and literary criticism, music, philosophy, religious studies, history, political science, sociology, anthropology, archaeology, science, and agriculture. Its journals include *The Chaucer Review, General Linguistics, Philosophy and Rhetoric, The Journal of General Education, Journal of Speculative Philosophy, Comparative Literature Studies,* and *The Journal of Policy History.* One of the leading publishers in art and architectural history, the press is the official publisher of the Monographs on the Fine Arts Series of the College Art Association of America, and in 1986 became the official publisher of the Memoirs and the Papers & Monographs Series of the American Academy in Rome. The press maintains sales and editorial offices in Europe and the Far East as well as at University Park.

THE COMPUTATION CENTER

The Computation Center provides computing facilities and support services for the instructional and research programs of all academic departments. More than 4,000 graduate students and faculty engaged in research and about 17,000 students doing class assignments use the Computation Center services in any one semester.

Two very large IBM 3090 systems are operated by the center. One of these, with 64 megabytes of main storage and 26 gigabytes of disk storage, a 20,000-reel tape library, and extensive computer software including modern programming language compilers and several thousand library programs, is primarily used for processing large batch computing jobs. There are 150 machine-readable data bases available, including hundreds of reels of tape from the 1970 and 1980 U.S. Census counts. This 3090 also controls fifty line printers, which are located in the Computer Building and ten other buildings at University Park and at twenty other Penn State campuses.

The second IBM 3090 system, with 128 megabytes of main storage and 22 gigabytes of disk storage, and two IBM 4381 systems each with 32 megabytes of main storage and 10 gigabytes of disk, are devoted to interactive computing. Up to 855 concurrent users connect to these three time-sharing nodes for interactive execution of their programs. The interactive computing nodes are networked with the batch computer to permit interactive users to submit batch jobs and to forward files for printing to any of the local or remote printers. Host-to-host networking has also been established with the Department of Computer Science, the Engineering Computer Laboratory, the Architecture Computer Laboratory, the Applied Research Laboratory, the Laboratory for Elementary Particle Science, the Library Information Access System, the Agricultural Extension Network computers, with nodes at Penn State-Behrend and the Altoona Campus of Penn State, and with three administrative computing installations at University Park. Through BITNET links, networking for electronic mail and file transfer is extended to some 1,700 computer nodes at more than 550 other universities and research organizations in the United States, Canada, Europe, and other areas.

Interactive access and remote printing is provided at terminal laboratories operated by the Computation Center in Hammond, Sparks, and Willard buildings at University Park and in facilities at twenty other Penn State campuses. Computer graphics services are offered in the Computer Building and in the laboratories in Hammond and Willard buildings.

Access to supercomputer facilities and the National Science Foundation Network is provided through a high-speed data channel from University Park to the John von Neumann Supercomputer Center in Princeton, N.J. Penn State is a member of the Consortium for Scientific Computing, which operates that center, and is also affiliated with three other national supercomputer centers.

A microcomputer teaching classroom is provided in Willard Building, and open microcomputer laboratories are available in Pattee Library, Findlay Commons, and Boucke Building.

Center faculty and staff generate extensive documentation describing services available and conduct computer application workshops, technical seminars, and guest lectures to acquaint the Univer-

sity community with available services and with advances in computing practice. Consultants provide advice and technical assistance to course instructors and research users. Except for a few holidays the center is operated twenty-four hours a day, seven days a week.

SPECIALIZED COMPUTING FACILITIES

Penn State also provides distributed computing and information systems. Many academic computing facilities exist to support the specialized research and instructional requirements of the colleges and the intercollege research programs. Some of these facilities are described below.

Colleges — In the *College of Arts and Architecture,* the Department of Architecture Com/CAD laboratory has a DEC VAX 11/750 with graphics equipment and CAD software. The laboratory supports instruction in CAD applications; its facilities are also used for research.

The *College of Earth and Mineral Sciences* has twenty-two minicomputers. Twelve of these are operated by the Department of Meteorology and are used for a variety of operational and research applications, including the collection of environmental data, weather forecasting, and satellite and radar image analysis. A DEC VAX 8200, three DEC VAX Station II workstations, and a PDP 11/23+ are used for real-time weather analysis, data processing, communications, and access to a decade of weather archives. The system is accessible by more than twenty terminals within the department supporting high-resolution graphics, laser printer products, and large screen color presentations during meteorology labs. The VAX systems are interconnected by a local area network allowing easy data interchange between systems as well as a connection to a campuswide network. In addition, the systems are connected to two worldwide networks operated by the National Science Foundation and NASA providing communications to the Computation Center and to several centers with supercomputers, including the National Center for Atmospheric Research. Live reception of satellite and radar imagery occurs on an ALDEN C2000/C3000 system. A Data General NOVA 4X performs weather radar control and signal processing. Two NOVA 2/10's are used for acoustic and turbulence data processing and a NOVA 4C for acid deposition and micrometeorological monitoring. Each of three VHF Doppler radars for wind profile study is equipped with a DATA General Eclipse S120 for signal processing.

In the *College of Education,* the Faculty Development Center, located in 202 Chambers Building, provides access, consultation, and information on microcomputing and educational applications of microcomputers for College of Education faculty. Various microcomputers, laser printers, and networked microcomputer applications are available for College of Education faculty use.

The Instruction Support Center, located in 201 Chambers Building, provides support to College of Education faculty in research and delivery of computer-based testing and computer-managed instruction. The center uses a Digital Equipment Corporation VAX Station II minicomputer to drive a network of student, author, and administrative stations.

The IBM Personal Computer Lab, located in 202 Chambers Building, provides microcomputer access to the University community. Twenty networked IBM personal computers are available for student and faculty use. (The lab is restricted during certain hours; check schedule outside 202 Chambers Building.)

The Department of Communication Disorders utilizes a DEC PDP 11/23 and several microcomputers to prepare instructional material for handicapped children and adults and to support research in communication disorders. One activity is speech synthesis research.

The *College of Engineering* Computer Laboratory is used for a wide range of instructional and research applications. The laboratory contains Digital Equipment Corporation VAX 11/780, 11/785, and 8550 systems, a DEC 2020, a DECsystem-10, a Harris HCX-7 mainframe, an IBM 4341 Model II system with advanced graphics workstations used for VLSI design and CAD/CAM applications, and a Computervision Designer V system with high-resolution color graphics. Software libraries are extensive and include program language compilers, scientific subroutines, and application programs for engineering, graphics, mathematics and statistics, microprocessor development, and text editing and processing.

The Noll Laboratory for Human Performance Research of the *College of Health and Human Development* has two DEC PDP 11/03's and a PDP 11/73 plus an IBM PC-2 to collect and process data from equipment used for physical performance testing and measurement. The Department of Psychology in the *College of the Liberal Arts* has a DEC PDP 11/34 that is used to control experiments and collect data in such areas as studies of brainwaves.

The *College of Medicine* at the Milton S. Hershey Medical Center operates a research computer facility containing a DEC VAX 11/780 with extensive graphics capabilities. It supports problem solving for research in anesthesiology, biochemistry, behavioral sciences, clinical pathology, endo-

crinology, radiology, etc. Of particular interest is research in computer graphics and modeling of biological macromolecules. There are also several smaller, dedicated computing facilities within individual departments.

In the *College of Science,* Chemistry and Computer Science faculty have departmental facilities.

The Department of Chemistry houses an IBM 4381 mainframe, a PRIME 750 minicomputer, two Floating Point Systems array processors, and numerous small computers such as Sun Workstations, DEC Microvaxes, and IBM PC's. The computers are networked via an Ethernet, which is connected to a Pronet system on campus through which the Computation Center and the NSF supercomputer centers are readily accessible. These systems are used for computational research as well as laboratory control of experiments. Present applications include classical dynamics simulations of molecular liquids and reactions of gases with solids, biomolecular modeling, graphic-aided analysis, pattern recognition, and electronic structure calculations.

The Department of Computer Science maintains Computer Systems Laboratories in 320, 321, 323, and 334 Whitmore Lab. The Computer Systems Lab provides facilities for both research and graduate instruction.

Facilities: Research equipment in the lab includes two Digital Equipment Corporation VAX 11/780s and a VAX 11/750, all running the UNIX operating system Version 4.3 from the University of California, Berkeley. UNIX features a powerful interactive text editor, a flexible hierarchical file storage system, and compiler-compilers, and supports software development in a number of programming languages. Two high-quality laser printers are provided for text processing.

For VLSI design, the department provides three MC68000-based CAD workstations, two Valid SCALD Stars, and a four-head color SCALD S-32. These systems run SCALD 8.2/VMUNIX. The machines communicate with each other over VNET and the other departmental machines over Internet. In addition, the VAXes are equipped with three AED 512 color graphics display terminals and VLSI design support software.

For Artificial Intelligence research, the department provides three Symbolics lisp machines; one is a 3670 with 8 MB main memory and 474 MB of mass storage; the other two are 3640s with 4 MB main memory and 280 MB of mass storage. The machines communicate with each other over Chaosnet and communicate with other departmental machines over Internet. A local area network consisting of six SUN workstations with access to VAX 11/780s is available for research in operating systems and related areas. More workstations are expected to be added shortly to the network. A GE Optomation image processor provides frame buffering of live video for experiments in image understanding conducted on the department's UNIX systems. AT&T Information Systems has donated eight AT&T 3B2/300 computers to the department. Each computer has 2 MB memory, a 32 MB disk drive, a 720 KB floppy disk, two terminals, and 3BNET interface among all AT&T machines. The System V UNIX Operating System and essential utilities are included with the packages as well.

Network Connections: Communication with other research facilities across the nation is maintained through NSFNET, BITNET, and USENET. A dedicated high-speed connection provides access between several of the department's machines and BITNET. Automatic dialers provide access to USENET through cooperating sites across the country. Through these networks, convenient and fast access to the nationwide computer science research community is available.

Access to the CDC Cyber 205 at the John von Neumann Consortium for Scientific Computing Center, of which Penn State is a member, is provided by a high-speed line between the Scientific Computing Center and Penn State.

The Biotechnology Institute Computing Center operates a research computer center specializing in molecular graphics, the analysis of gene and protein sequences, and general support of the institute's membership. The facility operates one DEC VAX 3600, one DEC MicroVAX II, one DEC GPX Graphics Workstation, one SUN Microsystems Workstation, and an Evans and Sutherland PS390 Graphics Workstation.

Many colleges operate computing laboratories that provide students and faculty with microcomputing capabilities and/or batch and interactive access to the University's principal academic computers in the Computation Center.

Intercollege — The *Applied Research Laboratory* Computational Facility has a DEC VAX 11/782 with software supporting graphics, interactive problem solving, and text processing. Uses include realtime data acquisition and data analysis for the water tunnel, acoustic tank, etc. The lab also has a Data General MV10000 with ADA programming language software.

The *Materials Research Laboratory* utilizes a dual processor DEC PDP 11/20 to support a number of interactive terminals, realtime experiments, a communications link with the Computation Center, and a network of microcomputers. Laboratory computing is particularly oriented to the development of microcomputer support for instrument control, data reduction, and information analysis.

GRADUATE LIFE

Current graduate enrollment at University Park is about 5,800 students, of whom 69 percent are engaged in graduate study full time, 38 percent are women, and 49 percent are residents of Pennsylvania. (Undergraduate enrollment at University Park exceeds 30,000.) International students comprise about 25 percent of the graduate student population, and about 6 percent of enrolling graduate students report themselves as members of recognized U.S. minority groups.

University Park is one of the most naturally beautiful American campuses. It is also one of the biggest. On any given day of the semester, about 49,000 people will be on the campus: 36,000 students, 12,000 employees, and several hundred visitors. Although the size of the campus can be intimidating, graduate students soon find that the size and diversity of the campus afford a variety of stimulating activities. This variety reflects the University's view that a person's graduate experience should mean more than doing what is required in courses or in research. It should mean living in a scholarly atmosphere, profiting from the perspectives of visiting scholars and artists, and engaging in informal discussions with faculty and fellow students. It should also mean participating in student affairs and university governance, and allowing time to reflect, to explore fields related to one's specialty, and to recreate.

Although the mailing address of the main campus is University Park, PA 16802, this name ordinarily does not appear on maps. The University Park Campus is located in State College, Pennsylvania, a metropolitan area of 67,000. State College is located on U.S. Highway 322, near Interstate 80, and can be reached directly by bus or airline service. The town retains a collegiate atmosphere enhanced by many small shops, restaurants, cinemas, and bookstores.

GRADUATE STUDENT ASSOCIATION

The Graduate Student Association (GSA) was established in 1951 as the representative body for graduate students, all of whom are automatically members, and is charged with designating graduate student representatives to a number of committees throughout the University. This volunteer organization provides services, programs, social activities, and student advocacy on pertinent issues. To help defray expenses, the association is partially funded through an allocation from the Student Organization Budget Committee.

The Graduate Student Association Assembly, the legislative arm of the association, consists of elected delegates from every graduate department, with voting rights proportionate to the number of students in the department. Also included as nonvoting *ex officio* members are the graduate students who have been elected to serve on the University Faculty Senate (three) and the Graduate Council (five). All members of the University community are invited to attend the regular Assembly meetings of the Association, which are held twice a month. An Executive Board, which consists of the executive officers, division heads, and representatives from Graduate Council and Faculty Senate, has interim powers to conduct business not requiring the specific action of the Assembly.

Members of the Assembly are required to sit on a committee in one of the four working divisions: Academics and Issues, Finance and Fundraising, Programming and Services, and Publicity and Publications. Any student, graduate or undergraduate, is welcome to serve on any of GSA's standing committees: Social, Happy Hours, Orientation, Teaching Assistant Issues, Newsletter, Tax, Explazaganza, Garden Plots, Guide to Grad Life, and Health. Often, an ad hoc committee is formed to address a particular issue.

The association maintains communication among its members through its monthly newsletter, the campus daily newspaper, scheduled meetings, and informal use of the Graduate Commons. It publishes annually the *Guide to Graduate Life*, an informal introduction to both the University and the community.

The Graduate Student Association office is at 305 Kern Graduate Building (814-865-4211). Graduate students are encouraged to bring any questions or suggestions about graduate life to the office.

KERN GRADUATE COMMONS

The Graduate Commons, located on the first floor of Kern Graduate Building, is part of the University's Division of Student Programs and is administered by the Office of Unions and Student Activities. It provides facilities, programs, and services for the graduate community and serves as a common meeting area for faculty and students. The assembly room and multipurpose rooms are used for large group meetings; the smaller rooms are used for committee meetings and similar small group gatherings. These may be reserved by graduate organizations or for events of a University-wide nature.

Food service is provided by the Department of Housing and Food Service in the cafeteria and for

special catered events. The lobby contains the Commons Gallery, which displays artwork and research displays done by students and faculty as well as exhibits from sources outside the University. The Commons also serves as the home for Graduate Student Association programs such as the coffeehouse, films, concerts, and similar events. Policy governing building use and services is determined by the director of the Office of Unions and Student Activities, who, when appropriate, consults with the vice president for research and dean of the Graduate School, the Graduate Council Committee on Graduate Student and Faculty Affairs, and the Graduate Student Association.

The Office of the Director of the Graduate Commons serves as a clearinghouse for scheduling events planned by organizations and individuals. Reservations, a periodicals lending library (including daily newspapers), information regarding Graduate Commons activities, recreational equipment, and information of a general nature concerning the Graduate School are available at the Graduate Commons Information Desk. The Commons is open seven days a week during each semester and summer session. The operating hours are posted at building entrances. For more information call the Information Desk at 814-865-1878.

CENTER FOR MINORITY GRADUATE OPPORTUNITIES AND FACULTY DEVELOPMENT

Increasing the enrollment of Black, Hispanic, and American Indian graduate students and ensuring that minority students at Penn State have a strong support network are top priorities of the Graduate School. The major source of financial assistance for minority graduate students is the Minority Scholars Program. Graduate minority recruitment and related activities are coordinated by the director of the Center for Minority Graduate Opportunities and Faculty Development. Prospective or currently enrolled graduate students who want additional information regarding minority programs should contact the director of the Center for Minority Graduate Opportunities and Faculty Development, 308 Kern Graduate Building, The Pennsylvania State University, University Park, PA 16802 (814-865-1663).

OFFICE OF INTERNATIONAL STUDENTS

The Office of International Students (OIS), a division of the Office of International Programs, and the International Lounge are located in 222 Boucke Building. There are approximately 2,000 international students from more than 100 countries studying at the various University campuses. Approximately 80 percent of these students are enrolled in graduate programs.

Services of OIS include assistance with immigration regulations and tax information; academic, financial, and personal/adjustment counseling; emergency loans; billing for sponsored students; assistance in dealing with embassies, consulates, and sponsoring agencies; special orientation programs; program advising; mail service; housing information; job and travel information; home country employment information; an international student newsletter; advising international student organizations; and sponsoring intercultural activities.

The International Lounge is a place where international and American students can meet informally. All students are welcome to participate in OIS activities. Announcements of events are posted regularly in the lounge. International Programs maintains a library of work/study/travel information as well as other reading materials, including dictionaries, encyclopedias, maps, arts and crafts books, and newspapers and magazines from around the world. The lounge is available for group programs upon request.

The OIS works closely with the Division of Student Programs, the State College Community International Hospitality Council (a local community volunteer organization), and the International Student Council and its twenty-four member international student organizations that represent international students at the University and promote a variety of social, cultural, and educational programs for the University community.

RECREATIONAL AND ATHLETIC FACILITIES

At University Park there are six modern gymnasiums, fifty-nine outdoor and four indoor tennis courts, one outdoor and four indoor swimming pools, two eighteen-hole golf courses, an ice-skating rink, twenty-six handball and paddleball courts, twenty-six bowling alleys, sixteen squash courts, indoor and outdoor running tracks, a baseball field, lighted intramural fields for football, soccer, rugby, and lacrosse, thirty-two acres of practice fields, and a four-mile jogging course. Rooms for weight training, fencing, archery, golf, body mechanics, dance, gymnastics, adaptive exercise, and wrestling are also available. The Stone Valley Recreation Area (located fourteen miles from Univer-

sity Park) provides sailing, boating, and picnic facilities. The wooded mountain country surrounding the campus offers outdoor recreation — swimming, boating, camping and trail packing, climbing, hiking, skiing, caving, and fishing.

THE ARTS

Each year, the University Center for the Performing Arts brings to the University a wide variety of programs usually available only in major cities. The Eisenhower Music and the Schwab Concert series bring symphony orchestras, opera, chamber ensembles, choruses, and jazz and folk music artists to the University. The Theatre and Dance series bring touring professional companies to perform modern and classical dance, plays, and musicals.

The University Resident Theatre Company combines professional theatre artists with student interns from the Professional Training Program and offers a year-round season of new and classic productions. The plays are presented in the Playhouse and Pavilion theatres offering both traditional and experimental staging.

The School of Music offers regular performances and recitals including solo artists, ensembles, and full orchestral concerts. The work is presented in the Music Recital Hall, as well as Eisenhower Auditorium and the Schwab Theatre.

The University Museum of Art galleries display traveling exhibits, as well as works selected from the permanent collection. Works in various media, including those of resident and student artists, are also displayed in the Zoller, Kern, Chambers, Pattee Library, and Hetzel Union Building galleries.

The Graduate Student Association, the Artists Series, and several other student associations and interest groups regularly show classic and recent films on campus, complementing the first-run fare of the eight commercial cinemas in State College. The size of the institution enables student groups to sponsor concert appearances by first-rank performers.

STUDENT SERVICES

The facilities and services outlined in the following paragraphs are available to graduate students.

HOUSING AND FOOD SERVICE

Eastview Terrace and Graduate Circle, both located on the eastern side of the campus and within comfortable walking distance of most of the campus, provide one- and two-bedroom apartments for graduate students with families.

The Eastview Terrace apartments are fire-resistant, steel-framework, one-story buildings. There are 46 one-bedroom units and 30 two-bedroom units. Rent includes water and TV cable only. Tenants pay for electricity, gas, and telephone. Water is heated electrically. The units are unfurnished except for electric stove and refrigerator. For every two units, there is a utility room with two stationary laundry tubs and storage space. Privately owned automatic washers may be installed in apartment kitchens only. Dryers are not permitted. No coin-operated facilities are available.

Graduate Circle has 144 one-bedroom apartments and 72 two-bedroom apartments in 16 two-story buildings of brick and frame construction. Rent includes all utilities (and TV cable) except for telephone. Each kitchen has a double stainless steel sink with disposal unit, a gas stove, kitchen cabinets, and an electric refrigerator. One-bedroom apartments have a built-in chest of drawers; otherwise, the units are unfurnished. There are no facilities for private washing machines in the apartments; however, ticket-operated laundries at nominal fees are provided in five of the buildings throughout the area. A basement storage locker is provided for each apartment.

Residence in Graduate Circle or Eastview Terrace Graduate Family apartments is limited to registered full-time graduate students who are candidates for advanced degrees. All students must live with their spouses and/or preschool children in the apartment. Families with children of school age (including kindergarten) or with children who will come of school age during the term of the lease cannot be considered for occupancy. The one-bedroom units are designed for a graduate student and spouse, and the two-bedroom units for a family with not more than two children. Rates and additional information can be obtained from the Assignment Office for Campus Residences, 101 Shields Building, The Pennsylvania State University, University Park, PA 16802, or telephone 814-865-7501.

Nittany Apartments, Penn State's newest single student housing complex, are for graduate students. The apartments are furnished. Each accommodates four students.

Two apartment styles are intended for graduate student occupancy. The two-story townhouse units, with a single bedroom for each student, have two bedrooms and a full bath upstairs, two bed-

rooms and a half bath with a living/dining area and kitchen downstairs. The four-bedroom garden apartments have the bedrooms, living/dining area, full bath, and kitchen all on the same floor.

Although the complex is coeducational, each apartment will house either all men or all women. All apartments are heated and air-conditioned using a heat pump system. Residents are expected to provide their own sheets, blankets, pillows, towels, and cooking and eating utensils.

Electricity for light, heat, cooking, and air conditioning, and telephone are not included in the rental rate. Residents must make arrangements for phone service, if desired, with Bell of Pennsylvania. Each apartment will be billed monthly by the University for electricity, and each apartment occupant will be required to pay an equal share.

McKee Residence Hall, located near the Kern Graduate Building, provides combined room and board accommodations for single graduate men and women. Most assignments are made to double rooms since single rooms are available for only one out of three students. Rates for room and board for this hall can be obtained from the Assignment Office. The Hetzel Union Building and Graduate Commons restaurants, cafeterias, and snack bars also are available for meals.

All rates are subject to change by action of the University.

Information on other living accommodations available in the community can be obtained through the following:

Graduate Student Association
305 Kern Graduate Building
The Pennsylvania State University
University Park, PA 16802
Telephone: 814-865-4211

Organization of Town Independent Students
101B Hetzel Union Building
The Pennsylvania State University
University Park, PA 16802
Telephone: 814-865-6851

State College Area Chamber of Commerce
131 Fraser Plaza, #3
State College, PA 16801
Telephone: 814-237-7644

Graduate students should arrange for their accommodations well in advance of the beginning of classes, because it may be very difficult to find convenient housing at the last minute. STUDENTS MUST BE ADMITTED TO THE GRADUATE SCHOOL BEFORE THEIR REQUESTS FOR ON-CAMPUS LIVING ACCOMMODATIONS CAN BE PROCESSED.

DISABLED STUDENT SERVICES

Penn State encourages academically qualified disabled students to take advantage of its educational programs. It is the policy of the University not to discriminate against persons with disabilities in its admissions policies or procedures or its educational programs, services, and activities.

The University is responsible for making all its programs and services available to all its students. In cases where it is necessary to provide auxiliary services and programs to meet the specific needs of disabled students, it is the responsibility of the coordinator of the Office for Disability Services to make reasonable accommodations. Examples of such accommodations available to those with special needs are sign language interpreters, accessible University transportation, and classroom and library assistance. Students anticipating the need for special services, both before and after enrollment, are encouraged to contact the coordinator of the Office for Disability Services (105 Boucke Building) at University Park or the director of student programs and services at other campuses.

UNIVERSITY HEALTH SERVICES

The University Health Service is located in the Ritenour Health Center. This facility is the core of the health service activities and is primarily an ambulatory-care center with a thirteen-bed observation unit. Its facilities are available to all students, including graduate students at all levels of training.

Conferees, visitors, and staff are seen on an emergency basis. The outpatient department handles medical problems from 8:00 to 11:45 a.m. and 1:00 to 4:45 p.m. daily except Saturdays when hours are from 8:00 to 11:45 a.m. During other periods, including Sundays and holidays, patients are seen for emergencies only in the Urgent Care Clinic. There is a $10.00 charge per visit for after-hours care.

The observation unit is well equipped to handle more serious illnesses and injuries on an inpatient basis. A thirteen-bed facility is staffed with professional personnel twenty-four hours a day during the school semester/session. Should the need arrive for special medical or surgical treatment — major surgery, for example — the student will be transferred to a personally chosen hospital facility.

Included in the Health Center facilities are a clinical laboratory, X-ray and physical therapy departments, a pharmacy, and a nutrition clinic. Health promotion opportunities are made available to all students by the Office of Health Promotion and Education. Workshops are sponsored and individual consultations are provided to address such topics as alcohol, nutrition, sexuality, contraception, and self-care as well as general health promotion and wellness.

The Women's Health Department offers examinations, contraceptive services, treatment of gynecological problems, pregnancy testing, and diagnosis. There is a $25.00 charge for the initial visit for contraception.

The University Health Services maintains an ambulance service for local transportation of students with nonambulatory illnesses and injuries.

There is no charge for consultation with the University Health Service's professional staff. Nominal charges are made for X-rays, lab, hospitalization, ambulance, and drugs dispensed to patients. Consultation with or treatment by a physician other than the professional staff at the Health Center is at the student's expense. All accounts should be settled before the end of the semester or session in which charges were incurred.

HEALTH INSURANCE

Accident and sickness insurance is available for graduate students, their spouses, and dependents. The program is underwritten by the Colonial Life and Accident Insurance Company. Information and applications are available at the University Health Services Business Office, 215 Ritenour Health Center.

In addition, Blue Cross/Blue Shield health insurance is available at group rates for full- and part-time graduate students, nondegree graduate students, and postdoctoral students. Coverage for spouses and dependents is also available. Additional information is available from the Graduate Student Association, 305 Kern Building, The Pennsylvania State University, University Park, PA 16802 (814-865-4211).

MEDICAID BENEFITS

Graduate students may qualify for most of the benefits that apply to hospitalization and medical treatment under Medicaid. Graduate students who are permanent residents of Centre County may apply for state medical assistance to the Office of the Centre County Board of Assistance, Bellefonte, PA 16823 (814-355-6000).

HEALTH SERVICES FOR CHILDREN

Many medical services are available for children under twenty-one through the State Health Center. The services range from simple immunizations to complicated surgery. Diagnostic study and consultation at the center are made regardless of the ability to pay; however, not all services are free. Children may be referred to the center by physicians or health and welfare agencies. Any preschool child is eligible for free well-child examinations and immunizations. For additional information, contact the Health Center at 280 West Hamilton, State College, PA 16801 (814-865-0932), or consult your doctor.

CAREER DEVELOPMENT AND PLACEMENT SERVICES

Career Development and Placement Services (CDPS) provides counseling and placement services to assist students in their career development and in formulating and implementing both short- and long-range career plans. Some of the specific services and programs offered by the center include the following:

Counseling Services — Counseling staff are available to meet with students both individually and in groups to assist with career concerns. Standardized test data, information resources, computer-assisted career planning, and educational programs described below are often employed to help students assess their abilities, attitudes and values, interests and aptitudes, and to relate these to job and career opportunities so that the student can make appropriate educational and vocational plans. Intake

counselors are available on a walk-in basis in 412 Boucke, Monday through Friday, from 8:30 a.m. to 5:00 p.m. The intake counselor provides initial assistance with career questions and can refer students to additional CDPS services.

Educational Programs — CDPS offers opportunities for students to participate in programs designed to develop specific skills such as career decision making and job search training.

Career and Employer Information Library — The library includes an extensive file, including videotapes, of general and specific information on careers and academic majors, information about employers, and a variety of other resources to assist students in choosing a program of study and a suitable career.

Placement Services — CDPS cooperates with the colleges and departments of the University to assist students in implementing career plans upon graduation. Services include (1) a library containing information on career opportunities, employer characteristics, and graduate and professional schools; (2) scheduling interviews with prospective employers who are visiting the campus; (3) a file of employment opportunities for which a student may apply by mail; (4) a listing of career-related summer jobs and internships; (5) workshops on interviewing skills, résumé preparation, and job search strategies; and (6) a variety of informational meetings and publications. CDPS is located on the fourth floor of Boucke Building; it is open during the lunch hour and also on Wednesday evenings from 5:00 to 7:00 p.m. to serve students better. The phone number is 814-865-2377; that is, 814-865-CDPS.

Alumni Career Service (ACS) — Alumni can enroll in ACS ($20 per year) in order to utilize the following aids in conducting their own self-directed job search:

1. Resource materials — These offer information about the proper preparation of résumés and letters of application and about the job search itself.
2. Professional résumé review and critique — CDPS counselors at any Penn State campus offer consultation on the job search and the review and critique of résumés and cover letters.
3. Résumé matching and referral — ACS registrants' credentials are compared with the human resource needs of participating employers; matching registrants' credentials are referred to the employers for any further contact.

Education Career Services (ECS) — Alumni seeking careers in education are eligible for the services of ECS. For the annual registration fee of $20, an educational credentials file is established, maintained, duplicated, and mailed to prospective educational employers. The first five mailings are included in the fee; the cost of additional mailings is $2 each. ECS will also send a weekly listing of job vacancies in education if provided with self-addressed, stamped, business-size envelopes. The education services officer is available to discuss registrants' educational career plans.

VETERANS OUTREACH OFFICE

The Veterans Outreach Office, 121 Grange Building, provides information on programs and services unique to veterans. (See Veterans' Benefits, page 33.)

TUITION, CHARGES, AND STUDENT AID

TUITION AND CHARGES 1987-88

The University reserves the right to revise the schedule of tuition and charges without further notice. Tuition rates for 1987-88, shown below, are rates for one 15-week semester of study under an academic calendar consisting of two 15-week semesters and an 8-week summer session per calendar year. The tuition figures below are for the 1987-88 academic year and may be changed for future academic years.

TOTAL TUITION FOR EACH SEMESTER IN 1987-88

University Park Campus and the Milton S. Hershey Medical Center (Nonmedical Students) — 12 or more credits, total charge of $1,755 for Pennsylvanians and $3,508 for non-Pennsylvanians; 11 or

fewer credits, $147 per credit for Pennsylvanians and $292 for non-Pennsylvanians. These rates apply also for off-campus research and other approved individual study.

Penn State-Behrend and Penn State Harrisburg — 12 or more credits, total charge of $1,755 for Pennsylvanians and $3,508 for non-Pennsylvanians; 11 or fewer credits, $147 per credit at Penn State-Behrend and Penn State Harrisburg for Pennsylvanians; $169 per credit at Penn State-Behrend for the M.B.A.; $292 per credit at all locations for non-Pennsylvanians.

Penn State Great Valley — Tuition at Penn State Great Valley is $169 per credit for Pennsylvanians and $292 per credit for non-Pennsylvanians.

Continuing Education Centers — Tuition for continuing education courses carrying graduate credit will be charged at the prevailing rate at the campus where the courses are offered.

Tuition is the same for courses whether audited or taken for credit.

Any student who does not fulfill payment obligations promptly may be charged a late payment fee of $25. A student whose account is delinquent for more than ten days is subject to suspension from the University.

Residency — When it appears that an applicant for admission is not a resident of Pennsylvania for tuition purposes, a non-Pennsylvanian classification is assigned. If the student who is thus admitted believes that circumstances do not justify classification as a non-Pennsylvanian, a petition can be made to the Assistant Bursar, 109 Shields Building, The Pennsylvania State University, University Park, PA 16802, for reclassification. (See Student Pennsylvania Resident Status, page 35.)

TUITION REFUND POLICY

Charges for tuition are refundable upon withdrawal from the University only in the event the student obtains an official Withdrawal Form at the Office of Graduate Student Programs and presents it, together with a current Certificate of Registration, at the Office of the Fee Assessor no later than one calendar month after the effective date of withdrawal from classes. Students who meet these conditions are entitled to receive refunds of charges for tuition for the semester, in accordance with the following schedule:

> Refund of 80 percent upon withdrawal before the end of the first week of the semester (seventh consecutive calendar day from the first day of classes) and a decrease of 10 percent for each week thereafter, up to and including the eighth consecutive calendar week. No amount will be refunded for withdrawal after the eighth consecutive calendar week of the semester.

Under this policy, if a student is enrolled for 12 or fewer credits and drops 1 or more credits, refunds will be determined in accordance with the above policy.

The University will not release any refund of tuition until at least three weeks have elapsed from the date the payment was received. All refunds will be made by check and mailed to the student's home address.

SPECIFIC CHARGES

In addition to the foregoing tuition and charges, the following charges apply under special conditions and are to be paid independently:

Application fee	$35.00
Change of schedule (each change after first five working days of semester)	6.00
Duplicate student identification and activity care	each 10.00
Music, individual lessons	60.00 to 100.00
Privilege of late payment	25.00
Privilege of late registration	10.00
Special Ph.D. thesis preparation registration fee (601, 611)	415.00
Student parking fee, each semester	15.00
Teacher placement service registration fee	10.00
Teacher placement service reactivation fee	10.00
Thesis Guide	1.50
Thesis microfilming and binding fee for master's candidate (one copy)	17.00
Thesis microfilming and binding fee for doctoral candidate (one copy)	55.00
Transcript of records (with seal), each copy	2.00
Mailing diploma in absentia	5.00

A surcharge for graduate students enrolled in the Colleges of Engineering, Earth and Mineral Sciences, and Agricultural Engineering will be assessed as follows:

9 or more credits	$150 per semester
5-8 or fewer credits	$90 per semester
4 or fewer credits	$45 per semester

A student's transcript, diploma, or both, may be withheld until any outstanding financial obligations to the University have been paid.

STUDENT AID

There are four separate avenues for graduate students to explore when seeking financial assistance. Most aid is awarded by the academic department, the Graduate School, the Office of Student Aid, or external agencies. The process for aid consideration is decentralized; consequently, it is necessary to file applications with each office.

The deadlines for submitting financial aid applications vary with each area. Early application for financial aid is recommended as these applicants are the most likely to receive favorable consideration. It is often desirable to apply by the first week in February for the succeeding year. It is best to apply for all sources of aid simultaneously, not sequentially in order of your preference. If you file sequentially in order of your preference, you may not get your first choice and may have also eliminated yourself from other alternatives due to missed deadlines.

The principal sources of financial assistance appear below.

ASSISTANTSHIPS

Approximately 2,300 graduate assistantships are awarded annually. An appointee may serve as an assistant in classroom or laboratory instruction, in research, or in other work.

A prospective student should write directly to the person in charge of the intended graduate major program for information. If you have indicated on the graduate admission application that you are interested in receiving a graduate assistantship, this person will send you the necessary application forms. Appointments are made subject to the student's receipt of a bachelor's degree and admission to the Graduate School as a degree or certificate student. Clear evidence of superior ability and promise is required. Reappointment to an assistantship is based on availability of positions and the quality of the student's work. In most departments or major programs the number of years an appointment may be renewed is limited.

The assistantships vary as follows: (See also *Visiting and Auditing Classes,* pages 39-40, and *Academic Credit and Employment,* page 41.)

QUARTER-TIME — The student normally schedules 9 to 14 credits per semester, receives a stipend plus a grant-in-aid of resident education tuition, and performs tasks that, on the average, occupy approximately ten hours per week.

HALF-TIME — The student normally schedules 8 to 11 credits per semester, receives a stipend plus a grant-in-aid of resident education tuition, and performs tasks that, on the average, occupy approximately twenty hours per week.

THREE-QUARTER-TIME — The student normally schedules 6 to 8 credits per semester, receives a stipend plus a grant-in-aid of resident education tuition, and performs tasks that, on the average, occupy approximately thirty hours per week.

The credit load limits specified above may be increased or decreased for a specific semester by permission of the assistantship supervisor, the student's adviser, and the senior associate dean, provided the total work load is properly balanced in each semester *and* the average credit load over a series of semesters is in conformity with the guidelines stated above.

A graduate assistant may accept concurrent employment outside the University only with permission from the assistantship department head and the assistant's graduate academic program chair. Concurrent employment normally may not be held with the University. A student may receive a concurrent fellowship supplement.

FELLOWSHIPS AND TRAINEESHIPS

About 200 fellowships and traineeships are awarded annually. Recipients must be superior students and are sometimes required to have completed a certain minimum of graduate work before being eli-

gible for an award. Fellows and trainees are required to carry at least 9 credits of course work each semester or the equivalent in research, receive stipends that vary with the awards, and usually receive grants-in-aid of tuition. They may not accept employment during the period of their appointments (except with special permission for training purposes) nor are they required to render any service to the University. In some cases, a recipient will be expected to engage in research in a broad field specified by the donor. There is no sharp distinction between a fellowship and a traineeship. Scholarly excellence is always a major consideration and usually the most important criterion in selecting fellowship recipients. Other considerations commonly come first in awarding traineeships.

When a graduate assistantship or fellowship for the next academic year is offered, the student, if acceptance is requested before April 15, will have complete freedom through April 15 to submit in writing a resignation of the appointment in order to accept one elsewhere. However, an acceptance given or left in force after April 15 commits the student not to accept another appointment without first obtaining a formal release.

Selection of recipients of all University awards is made without regard to the sex, race, religious belief, ethnic origin, handicap, or age of the applicant, as provided by law.

Graduate School Fellowships — Graduate School Fellowships are awarded by the Graduate School to a limited number of scholastically outstanding students. In 1987-88, Fellows received stipends of $7,000 and received payment of tuition. Fellows are required to enroll as full-time students. For incoming students, the graduate admission application serves as the fellowship application. Application forms can be obtained from the Graduate School Fellowship Office, 318 Kern Graduate Building. Applications must be submitted through the applicant's graduate major program and must be received by the Graduate School by March 1 to be considered for the following year. Graduate Record Examination verbal, quantitative, and analytical test scores, or other accepted test scores approved by the dean of the Graduate School, are required of all applicants.

Minority Graduate Scholars Awards — These are fellowships, assistantships, and fellowship supplements granted to incoming students as a part of the University's comprehensive educational opportunity program. The graduate admission application serves as the Minority Graduate Scholars application. For more information contact the Graduate School Fellowship Office, 318 Kern Graduate Building.

External Fellowships and Traineeships — More than 200 such awards, with various stipends, are granted through individual departments and state and national organizations. These awards are shown with the pertinent graduate program description under GRADUATE PROGRAMS, FACULTY, AND COURSES in the *Graduate Bulletin*. Information and application forms can be secured from the person in charge of the appropriate graduate program. Specific awards will vary somewhat from year to year.

In addition, grants are available from governmental agencies, industrial concerns, foundations, and the armed forces for graduate study and frequently for support of investigations of particular problems. Detailed information can be secured from the department of specific interest. Information on external funding opportunities is available in the reference areas of the libraries. The following directories may be helpful:

Financial Aids for Higher Education (Oreon Keeslar)
Annual Register of Grant Support (Marquis Academic Media)
Educational Financial Aids (American Association of University Women)
A Selected List of Major Fellowship Opportunities and Aids to Advanced Education for U.S. Citizens (National Science Foundation)

OTHER AIDS

Graduate School Tuition Grants-In-Aid — A number of grants of tuition remission for a semester of full-time study are awarded each year. Applications are available to any graduate degree or certificate student during or after the second semester at the University. Financial need and academic promise are the criteria for selecting recipients. A recipient must carry at least 9 credits of graduate work. Summer session tuition grants-in-aid are also available. Application forms and information on application deadlines can be obtained from the Graduate School Fellowship Office, 318 Kern Graduate Building.

Employment and Loan Programs Available Through the Office of Student Aid — Any prospective or current graduate degree candidate who is a U.S. citizen or permanent resident may seek aid from the federally funded loan and employment programs. Applications can be obtained from 335 Boucke Building.

To be considered for these aid programs, a prospective graduate student must

1. file by February 15 a Financial Aid Form (FAF), a document used to assess a student's financial need, with the College Scholarship Service, Box 176, Princeton, NJ 08540, or file a Graduate and Professional School Financial Aid Summary (GAPSFAS) with the Educational Testing Service, Box 2614, Princeton, NJ 08541.
2. file by April 1 an Application for Financial Aid and a Financial Aid Transcript with the Office of Student Aid. For each postsecondary institution the student has attended, a separate Financial Aid Transcript, certified by that institution, must be submitted. This form is available from the Office of Student Aid.

In order to be considered for any of the federal aid programs (Perkins Loans, Work Study, or Guaranteed Student Loan), a Financial Aid Transcript is required of all students who have attended an institution other than Penn State whether or not aid was received. Financial Aid Transcript forms are available through the Office of Student Aid, 335 Boucke Building, or the financial aid office at your prior institutions.

On-time applications receive first consideration. Because funds are limited, applications filed after the deadlines are considered only as funds permit. Aid is never automatically awarded for subsequent years. Students must reapply each year for funds. Students planning to attend during the summer must file separate applications.

The Graduate Work Study Program is a part-time employment program awarded to graduate students who show a documented financial need. Responsibilities and assignments are similar to those associated with graduate assistantships. This type of aid is rarely available to a student who accepts a graduate assistantship because of the difficulty of holding two jobs concurrently and the potential for a student's total aid resources to exceed his or her documented financial need.

The Carl D. Perkins Loan Program (formerly the National Direct Student Loan Program) makes low-interest loans available to full-time students with a documented financial need. Repayment begins nine months after graduation or termination of graduate work at a 5 percent interest rate.

University Loans are funds established by University organizations, alumni, faculty, staff, and friends to help students who have a documented financial need. Repayment begins after graduation or termination of study. Interest at the rate of 6 percent will accrue throughout the in-school period.

The Guaranteed Student Loan (GSL) Program provides low-interest loans to students enrolled on at least a half-time basis. The loans are repayable after the student graduates or terminates his or her education. This federal financial aid program is a cooperative effort of the federal government, state government and/or guarantor agency, a commercial lending institution, and the educational institution.

An application should be obtained from a lending institution that agrees to participate with the student in this program. The loan is available on an interest-free basis to students during their graduate enrollment. All students must file a Need Analysis document to determine their financial need for GSL funds. Additional information about this process and about the Higher Education Loan Plan can be obtained from the Office of Student Aid. An enrolled student's interest payments on the outstanding loan principal are paid by the federal government. The maximum loan for one year is $7,500. For students who are first-time GSL borrowers, the interest rate is 8 percent. A 5 percent origination fee is deducted from each GSL by the lender.

Nondegree Students — Financial aid is available for graduate students who are degree, provisional, and certificate students only. Nondegree graduate students are not eligible for assistance.

Federal Student Assistance Satisfactory Academic Progress Standard — Satisfactory academic progress must be maintained for continued consideration for federal financial assistance at Penn State. Students must comply with the following to ensure continued consideration:

1. Meet minimum standards for satisfactory scholarship as established by the University Graduate Council presented in *The Pennsylvania State University Bulletin, Graduate Degree Programs.*
2. Meet minimum semester earned-credit–level expectations as published in the current Penn State *Policies and Rules for Students.* Copies of the academic standards are available in handbook form from the Office of Student Aid.

3. Complete the requirements for the graduate degree within the time frame as indicated in the *Graduate Bulletin*.

Exceptions to the above and information concerning reinstatement of aid, course audits, deferred grades, and course repeats can be obtained by contacting the Office of Student Aid.

Additional information can be obtained from the Office of Student Aid, 335 Boucke Building, The Pennsylvania State University, University Park, PA 16802. In corresponding with this office, specify that you are a current or prospective graduate student, and if the latter, the semester or summer session you want to begin graduate study at the University.

GUIDELINES FOR TOTAL ALLOWABLE RESOURCES

Fellowships and assistantships are offered with the provision that permission must be granted from the first awarding department/agency before a second fellowship or assistantship can be held simultaneously.

Federal aid recipients are under federal regulations.

If a student receives a Guaranteed Student Loan, a Carl D. Perkins Loan, or a Graduate Work Study job, federal regulations require that the total financial aid resources not exceed the student's documented need. If the total aid exceeds the need figure, it may be necessary for adjustment of federal and/or University funds. If an adjustment is not possible because the funds have been used by the student, an overaward results. In the case of an overaward, a student may be required to repay federal and/or University funds that exceed the documented need. Students with graduate assistantships or fellowships who receive federal aid during the same academic year (including summer) should be careful to adhere to these regulations. For additional details on these programs, contact the Office of Student Aid, 335 Boucke Building, The Pennsylvania State University, University Park, PA 16802.

Student Employment — Many students depend upon part-time employment to help meet their expenses. Students must recognize the time demands of their work schedules and adjust their academic loads accordingly. The Office of Student Employment, 335 Boucke Building, offers assistance in finding part-time employment in the State College community, as well as on campus. This office assists students in finding summer employment. The Office of Student Aid coordinates the Graduate Work Study program, described above under Loan and Employment Programs.

Local placement services and the University Office of Personnel maintain files of positions open to spouses of students.

A student holding a fellowship or traineeship may not accept employment of any kind for service without special advance approval. A graduate assistant may accept concurrent employment outside the University only after obtaining permission from the department head and person in charge of the major program. Concurrent appointments with the University other than a Fellowship Supplement normally may not be held.

Veterans' Benefits — The coordinator of veterans affairs has the responsibility of handling all applications for benefits under the various public laws. Veterans who intend to enroll at the University should contact the Veterans Outreach Office, 121 Grange Building, The Pennsylvania State University, University Park, PA 16802; 814-863-0465, as far in advance as possible to obtain information and necessary forms. The Outreach Office also provides information on other programs and services unique to veterans.

Veterans in their first semester may defer tuition and room and board fees until their benefit checks begin to arrive. Veterans who need this deferral should contact the veterans counselor, 121 Grange Building.

Federal law and Veterans Administration regulations specify the conditions under which veterans who are students and eligible dependents of veterans are paid VA educational benefits. Veterans Administration benefits are paid under the federal standards of academic progress (see page 31) and policies relating to student conduct contained in this bulletin and that apply to all graduate students. In addition, payment of VA educational benefits require the following:

1. Courses that do not meet graduation requirements in the student's approved major (the major that the student has declared to the VA) cannot be computed as part of the student's course load for payment of VA benefits.
2. Unless mitigating circumstances exist, VA benefits cannot be paid for attendance of any portion of a course or semester that is not completed.
3. Unless *specific documentation* of an identifiable professional or academic goal can be provided (e.g., teachers requiring 24 graduate credits to obtain permanent certification), no vet-

eran or eligible dependent may be certified for payment of VA educational benefits for any semester subsequent to one during which he or she accumulates 18 credits on a nondegree status.

4. Since a 3.00 cumulative grade-point average is required for graduation, veterans who are graduate students and eligible dependents will be warned that their VA educational benefits may be suspended if their cumulative grade-point average falls below 3.00 during any given semester. If the student's average remains below 3.00 for a second consecutive semester, the VA certifying official will request a determination of whether progress has been satisfactory from the appropriate department head. If it has not, the VA certifying official will suspend benefits and report the veteran to the VA for lack of satisfactory progress.
5. Veterans and eligible dependents must report any change in academic status (change of credit load, change of major, etc.) to the Office of Veterans Programs or other appropriate VA certifying official promptly and personally.

APPLICATION AND ADMISSION PROCEDURES

STATEMENT OF NONDISCRIMINATION

The Pennsylvania State University, in compliance with federal and state laws, is committed to the policy that all persons shall have equal access to programs, admission, and employment without regard to race, religion, sex, national origin, handicap, age, or status as a disabled or Vietnam-era veteran. Direct all affirmative action inquiries to the Affirmative Action Officer, Suzanne Brooks, 201 Willard Building, The Pennsylvania State University, University Park, PA 16802; (814) 863-0471.

ADMISSION

Each step of the educational process, from admission through graduation, requires continuing review and appropriate approval by University officials. The University, therefore, reserves the right to change the requirements and regulations contained in this bulletin and to determine whether a student has satisfactorily met its requirements for admission or graduation, and to reject any applicant for admission for any reason the University determines to be material to the applicant's qualification to pursue higher education.

An applicant for admission to the Graduate School should understand that graduate work is not a simple extension of an undergraduate program but, rather, demands scholarship of a higher order, and emphasizes research, creativity, and professional competence with a minimum of formal requirements and a maximum of student initiative and responsibility.

Objective — The objective of the Graduate School is to admit a qualified graduate student body up to the limit of the University's resources to provide outstanding graduate programs. In general, a student may begin graduate work in the fall or spring semester or in the summer session.

Applicants must recognize that staff, facilities, and other resources are limited, so that not all qualified persons can be admitted. The number accepted will vary by program and from semester to semester. In some graduate programs all vacancies will have been filled long before the general Graduate School deadline for submitting applications, so that even outstanding students cannot be accepted.

Application — Applicants interested in graduate programs offered at the University Park Campus or the Milton S. Hershey Medical Center should apply to University Park. Those interested in programs at Penn State Harrisburg, Penn State Great Valley, or Penn State-Behrend should apply directly to the appropriate campus. Students are normally expected to begin work at the campus to which they are admitted. Addresses are listed on pages 17 and 18.

Qualifications — For admission to the Graduate School, an applicant must have received, from an accredited institution, a baccalaureate degree earned under residence and credit conditions substantially equivalent to those required by Penn State. Ordinarily, an entering student must have completed in a satisfactory manner a minimum of course work in designated areas, the specific courses and amount of work depending upon the field of advanced study. Scores on the Graduate Record Examination (GRE) Aptitude Test (verbal, quantitative, and analytical) are required by most programs. Individual program requirements for admission are included in this bulletin under the specific program

descriptions. The GRE is offered at convenient locations, several times each year. The schedule of offerings can be obtained from the Graduate School Information Center or from the Educational Testing Service in Princeton, NJ 08541.

A baccalaureate degree holder with a slight deficiency in undergraduate preparation may be admitted and allowed to schedule a limited number of undergraduate courses to remove the deficiency while proceeding in the graduate program. Courses taken for this purpose do not apply toward the requirements of the advanced degree.

Provisional admission may be granted to applicants whose credentials are not complete at the time of application because the baccalaureate degree has not yet been conferred, grades for the current semester are not yet available, etc. Such admission is subject to cancellation if the complete credentials, on arrival, do not meet the requirements for admission. In the interim, certification of any earned credits will be withheld. If admission is canceled for any reason, the student thereby is dropped automatically from the Graduate School. Completion of admission in such cases is dependent upon receipt of the missing credentials. (See Provisional Admissions, page 36.)

Admission is granted jointly by the Graduate School and the department or graduate program in which the student plans to study. The establishment of standards by which applicants are admitted is a departmental or program responsibility. Although the Graduate School has no fixed minimum grade-point requirement for admission, an applicant is generally expected to maintain a junior-senior grade-point average of at least 2.50 on Penn State's grading scale of A (4.00) to D (1.00). Individual programs often establish higher grade-point average requirements and use other criteria to judge candidates for admission. In exceptional cases, departments or major programs may also approve admission by reason of special backgrounds, abilities, and interests. Departmental or program requirements are given in the descriptive statements appearing under the graduate programs listed in the latter part of this publication.

A student who has been admitted to a program in which the doctorate is offered may begin working toward that degree but has no official status as a doctoral student and no assurance of acceptance as a doctoral candidate until a candidacy examination administered by the major department or committee has been passed.

Forms — Application forms can be obtained from the Office of Graduate Admissions. Applicants may apply for admission to only one program at a time. Two official transcripts from each institution attended, including an explanation of the grading system used, should be submitted to the Office of Graduate Admissions, 201 Kern Graduate Building, University Park, PA 16802. These must be received from all institutions by the Graduate School at least one month prior to the opening of the semester or summer session in which the student plans to begin a graduate program.

Deadlines — The deadline for processing of applications by the Graduate School is one month prior to the beginning of any given semester or session. GRADUATE MAJOR PROGRAMS MAY REQUIRE EARLIER DEADLINES. A complete Graduate School admissions file, which is required for processing an application, includes the following: (1) application form, (2) application fee form, (3) a check or money order in the amount of $35.00 made payable to The Pennsylvania State University, and (4) two official transcripts from each institution of higher education attended. Supplementary materials and examination scores may be required in individual programs. If the admission file is incomplete a month prior to the beginning of the semester or session for which the student has applied, the materials will be processed for the first semester or session following the completion of the admissions file.

Special Nondegree Status — A student who plans to take courses for transfer to another institution or to follow a program of study not leading to an advanced degree at this institution should apply for admission as a special nondegree student. The number of special nondegree students who can be admitted is limited because preference is given to students in degree programs.

Minority Students — Minority students are encouraged to apply for admission to any of the programs offered in the Graduate School. Information concerning programs and financial aid can be obtained from the chair of the graduate program, the dean of the college of the student's major interest, or from the Center for Minority Graduate Opportunities (309 Kern Building).

International Students — International students should plan to apply at least four months prior to the beginning of the semester or summer session in which they intend to begin graduate studies. They must submit two certified English translations of all academic records. In addition, all international

students whose native language is not English must take the TOEFL (Test of English as a Foreign Language) and submit the results of this test with the application for admission. A student must present a minimum TOEFL score of 550 to be considered for admission. International students who have been admitted to graduate study with TOEFL scores of 550 or higher will be considered to have met the Graduate School's English language requirement. Information about the TOEFL can be obtained by writing to the Educational Testing Service, Box 899, Princeton, NJ 08541. A grade of A in SPCOM 115G and 116G is an acceptable equivalent to a score of 550. Students can sign up for the TOEFL test with the Intensive English Communication Program, Faculty Building. International students are admitted only as degree students unless a sponsoring agency requests a different classification. Such students must also fulfill the Graduate School English language proficiency requirement.

Undergraduate Students — A student at Penn State who is within 3 credits of completing the baccalaureate degree may be admitted provisionally to the Graduate School. This limit may be increased to 9 credits in the case of a student with an average of at least B (a grade-point average of 3.00). Any senior with a 3.50 grade-point average may be admitted to 500-level courses with the consent of the instructor; other seniors with a B average or better may be admitted to graduate courses with the consent of the instructor, the student's academic adviser, and the senior associate dean of the Office of Graduate Student Programs.

In certain cases undergraduate students may subsequently apply credits they have earned in 400- and 500-series courses toward an advanced degree at Penn State. Upon admission to the Graduate School, and with the approval of the major field, a maximum of 6 credits *relevant* to the graduate program of study that were not used to satisfy undergraduate requirements may be applied toward an advanced degree. The time limitation on the completion of a master's degree program applies to these as well as to other credits.

Postdoctoral Fellows, Scholars, and Guests of the University — Postdoctoral Fellows appointments are financed under a Postdoctoral Fellow Program of a granting agency outside the University. A Postdoctoral Scholar is the usual designation for all other postdoctoral appointments that meet the standards enumerated by the National Research Council. Postdoctoral appointments are considered as appointments of a temporary nature that are intended to offer an opportunity for continued experience in research or teaching, usually, though not necessarily, under the supervision of a senior mentor.

Individuals holding the highest degree in their field from Penn State or other accredited colleges and universities are invited to apply to the senior associate dean of the Graduate School for guest privileges for purposes of noncredit study. Guests may attend seminars and courses with the privileges of faculty members and, if space and facilities are available, carry on research. Individuals may also be appointed to temporary positions in all University ranks. All guests are expected to affiliate formally or informally with one of the departments, institutes, or other subdivisions of the University engaged in scholarly pursuits.

It is the policy of the Graduate School not to encourage applicants to work for a second doctoral degree.

Student Pennsylvania Resident Status — When it appears that an applicant for admission is not a resident of Pennsylvania for tuition purposes, a non-Pennsylvanian classification is assigned. If the student who is thus admitted believes that circumstances do not justify classification as a non-Pennsylvanian, a petition may be made to the Assistant Bursar, 109 Shields Building, The Pennsylvania State University, University Park, PA 16802 for reclassification. Penn State Harrisburg students may petition the Penn State Harrisburg financial officer.

A copy of the *Policy for Determination of Eligibility for Reclassification as a Pennsylvania Resident for Tuition Purposes* can be obtained in the office of the assistant bursar mentioned above and should be reviewed before requesting reclassification. Any reclassification resulting from a student's challenge shall be effective for tuition purposes as of the date such challenge was filed. A student who changes residency from Pennsylvania to another state must promptly give written notice to the University.

TRANSFER CREDIT

Subject to the limitations given below, a maximum of 10 credits of high-quality graduate work done at an accredited institution may be applied toward the requirements for the master's degree. However, credits earned to complete a previous master's degree may not be applied to a second master's degree program at Penn State .

The student should distinguish carefully between the transferability of credit and its applicability in a particular degree program. Approval to apply any transferred credits toward a degree program must be granted by the student's academic adviser, the program head or graduate officer, and the Graduate School assistant director of admissions. Transferred academic work must have been completed within five years prior to the date of first degree registration at the Graduate School of Penn State, must be of at least B quality, and must appear on the graduate transcript of an accredited university. Credit earned externally in postbaccalaureate professional degree programs (law, medicine, etc.) is not transferable.

Pass-fail grades are not transferable to an advanced degree program unless the "Pass" can be substantiated by the former institution as having at least B quality.

Forms for transfer of credit can be obtained from the Office of Graduate Admissions, 201 Kern Graduate Building.

CREDIT BY EXAMINATION

Examinations to establish credit for work done in absentia or without formal class work may be used to remove undergraduate deficiencies, but *not* to earn credits toward an advanced degree. Arrangements are made by the student directly with the major department head or program chair.

CLASSIFICATION OF STUDENTS

A graduate student may be admitted as a degree student, a certificate student, or a special nondegree student, depending upon the student's objectives. A student who has held only nondegree or certificate status and who now wants to apply for degree status must apply through the Office of Graduate Admissions, 201 Kern Building. Any other change in classification must be arranged through the Office of Graduate Student Programs.

Degree Students — A degree student is one who plans to become a candidate for an advanced degree at Penn State and who has been formally admitted for advanced studies in a particular program. The program of study is developed under the guidance of an adviser appointed by the head of the student's major program. A degree student who has passed a candidacy examination is classified as a doctoral candidate.

Provisional Admissions — Provisional admission is a temporary classification in which an applicant may remain for a period no longer than the first semester following admission or the time it takes to accrue 15 credits, whichever comes first. If the deficiencies that caused the provisional admission are not corrected by this time, the student may be dropped from the program.

Special Nondegree Students — An applicant who meets all requirements for admission to the Graduate School, but who does not want to work for an advanced degree at this institution, may arrange for a program of work as a special nondegree student. This classification includes students who plan to transfer credits to another institution, casual students, and those who plan special programs of study not connected with a specific department and not leading to an advanced degree. The number of special nondegree students who can be admitted directly by the Graduate School is limited. Preference is given to students in degree programs.

A maximum of 15 credits earned as a special nondegree student may be applied to a degree program, with departmental approval. Normally, the credits must have been earned within five years preceding entry into the degree program. Forms to transfer nondegree credits are available in the Office of Graduate Student Programs, 211 Kern Building.

Certificate Students — A certificate student is one who is engaged in a program of study leading to a certificate or equivalent recognition of accomplishment rather than a graduate degree program at Penn State. Certificate students have the same University privileges and responsibilities as graduate degree students. For information on University certification programs approved by the Pennsylvania Department of Education, see page 59.

Undergraduate Students — Such a student is not a graduate student because a baccalaureate degree has not been attained. The student may not register for graduate courses or research (500 and 600 series) without permission from the Office of Graduate Student Programs. A student who has attained junior standing in college may register for 400-level courses and is admitted through undergraduate admissions.

PROCEDURES AND REGULATIONS FOR STUDENTS ENROLLED IN THE GRADUATE SCHOOL

It is each student's responsibility to know the regulations and pertinent procedures of the Graduate School as set forth in the Graduate Degree Programs Bulletin *and in the* Thesis Guide *and to meet the standards and requirements expressed by these regulations.* Copies of the *Graduate Bulletin* are available from the Graduate Commons Information Desk, 113 Kern Graduate Building; the *Thesis Guide* can be obtained from the Thesis Office, 303 Kern Graduate Building. Graduate students are encouraged to contact the Office of Graduate Student Programs, 211 Kern Graduate Building (814-865-1834), for guidance if they have any questions, uncertainties, or difficulties concerning any procedure or regulation of the Graduate School or any procedure or regulation of the University as it may affect them.

It is also the responsibility of students to be familiar with the rules, regulations, and procedures of the University. This information is contained in the *Policies and Rules for Students* available from the Center for Assistance and Information (135 Boucke Building) and each college dean's office at University Park.

PROGRAMS

Major Program — A directory of programs and degrees appears on pages 6 and 7. A student's major program is the field of primary interest and the one in which the greater portion of graduate work is taken. Programs are designed to prepare students to assume positions of informed and responsible authority in their fields and to contribute creatively to them. They promote not only specialization, but also breadth of scholarship, the ability to study and think independently, and familiarity with the principal techniques and important literature in the field. The research undertaken by the candidate should deal with a problem that represents a significant contribution to knowledge.

In general, departments of the University are identified with specific major programs. Thus, aerospace engineering is the program of study that is offered by the Department of Aerospace Engineering. In some cases, a single department offers work in more than one degree program. For example, the Department of Geosciences offers programs in geochemistry and mineralogy, geology, and geophysics. Occasionally, two or more departments within a college collaborate in offering an interdisciplinary program, such as the neuroscience major within the College of Medicine.

Intercollege Graduate Programs — When faculty members from departments in two or more colleges collaborate in offering a graduate major, the program is designated as an *intercollege* graduate degree program. A committee of graduate faculty members approved by the Graduate School is responsible for administering the program under a program chair. The University currently offers fourteen such programs, primarily at the doctoral level. They are included and identified in the listings on pages 6 and 7. Students interested in these programs should contact the program chair listed in the program description in this bulletin.

Special Interdisciplinary Majors — In addition to the graduate major programs listed in this bulletin on pages 6 and 7, special individualized interdisciplinary majors may occasionally be arranged with the approval of the senior associate dean of the Graduate School. These programs are planned, reviewed, and carried out under the supervision of appropriate interdepartmental or intercollege committees.

Since such programs are individually planned, each must be unique. A special interdisciplinary program will be considered for development and possible approval only if no existing graduate program can meet the needs of the student.

Individualized degree programs are not available at the master's degree level. Normally, a student considering an individualized interdisciplinary doctoral program should present a master's degree as one of his or her qualifications.

ADVANCED DEGREES OFFERED

The degrees of Doctor of Philosophy and Doctor of Education are conferred by the University. Both require high attainment and productive scholarship, but the Ph.D. places a strong emphasis on research, whereas the D.Ed. emphasizes professional competence in some field of education.

The Master of Arts and the Master of Science degrees are academic in nature, the programs placing strong emphasis on basic knowledge and research. The professional master's degrees conferred are

the Master of Agriculture, Master of Business Administration, Master of Education, Master of Engineering, Master of Environmental Pollution Control, Master of Fine Arts, Master of Forest Resources, Master of Health Administration, Master of Landscape Architecture, Master of Music, Master of Psychosocial Science, Master of Public Administration, and Master of Recreation and Parks.

Graduate degree programs are offered at five campuses of the University: University Park Campus (State College); Penn State Erie, The Behrend College (Erie); Penn State Harrisburg, The Capital College (Harrisburg); The Milton S. Hershey Medical Center (Hershey); and Penn State Great Valley (Malvern). Although programs offered at all five sites are described in this bulletin, each graduate center other than University Park also issues its own informational bulletin as well, which should be obtained and studied by those intending to pursue graduate work at that campus. Addresses are given on pages 17 and 18.

REGISTRATION

A graduate student who is *in residence* at the University is expected to be *properly registered. In residence* means that the student (whether full time or part time, and whether commuting to campus or other instructional site, living nearby or living on campus) is pursuing graduate credits and/or an advanced degree by (a) attending classes or seminars for credit or audit; (b) doing a thesis, term project, independent study, or similar research or scholarly work in a University laboratory or other research facility; (c) consulting in person or by other means of communication with one or more faculty members on scholarly matters, research projects, or dissertation; (d) using the library, Computation Center, or other University information resources; or (e) using other University facilities provided for graduate study.

The responsibility for being *properly registered* rests first with the student and secondarily with the student's adviser if the student has one (nondegree students may not). A student may register for course work or research or a combination of the two. In the case of research, the number of credits shall be determined by the amount of time devoted to the investigation, with 1 credit representing approximately the equivalent of one week of full-time work. In the later stages of the program, the situation will determine the requirements for the student's registration. (See Registration Near the Completion of a Program, page 44.)

Advisers — Advising is an important factor in enhancing the quality of a student's program. To assist the student in planning a coherent program and meeting all degree requirements, the head of the major department or program chair will designate a member of the faculty to serve as adviser. It is the student's responsibility to secure the name of an adviser from the department or program and to seek a conference before each registration.

Time of Registration — Registration days are indicated in the calendar at the beginning of this bulletin.

A student is expected to complete registration during the officially designated period and to attend the first meeting of all classes. If this is impossible because of some emergency or unusual circumstance, the student may be granted permission by the instructor to miss a few class meetings, it being understood that work missed will be made up subsequently. Under these conditions permission may be granted through the Office of Graduate Student Programs for the student to register late. In general, a student who receives permission to register late will be required to reduce the course load in proportion to the length of the absence.

A student who fails to complete the process of registration within the officially designated registration period will be liable for the late registration charge, regardless of when the student begins attending classes.

Continuity of Registration — A student who registers at any of the five graduate campuses of the University without interruption for each fall and spring semester is considered to have maintained a normal continuity of registration. A student who has been admitted as a "summers only" D.Ed. candidate (see D.Ed. Residence Requirements) can maintain continuity by registering each summer for the six- or eight-week summer session.

Anyone who has interrupted such a normal sequence and now plans to register for work at the University Park Campus is required to apply to the Office of Graduate Student Programs, 211 Kern Graduate Building, at least one month before the time of registration for permission to resume study.

The policy may be summarized for any specific semester or session as follows:

Summer Session — Application required unless the student was registered at the University Park Campus for the preceding spring semester or the preceding summer session.

Fall Semester — Application required unless the student was registered at the University Park Campus for the preceding summer session or the preceding spring semester.

Spring Semester — Application required unless the student was registered at the University Park Campus for the preceding fall semester.

Withdrawal — The dropping of all academic work for which a student is registered in any semester constitutes withdrawal from the University. An application for readmission must then be submitted and approved if the student wants to enroll for further work.

Procedure — For each registration, the student, *in consultation with the adviser,* prepares a schedule of courses and research designed to fit individual needs. The credit load will be reviewed at the time of registration. The registration process is completed in the manner specified for all students at the University.

Under certain conditions credit may be earned for work done away from the campus. A student contemplating such work should inquire at the Office of Graduate Student Programs about the procedures and conditions. The student must assume responsibility for the registration process, but the operation can be handled by mail. Registration must be completed before the close of central registration at University Park.

A student must register for courses audited as well as for those taken for credit.

GRADUATE CREDITS

Typically, a candidate for an advanced degree is required to earn a certain minimum number of credits at Penn State. Consequently, there is a limit to the number of credits that may be earned at another approved institution or through continuing education to meet the minimum requirements of the degree. Moreover, the department or committee in charge of a major program may require a student to do more of the work at the University than specified by the limitations set by the Graduate Faculty.

Full-time participation in graduate study involves a wide range of activities. The nature of these activities varies because of the diversity of programs throughout the University. The graduate student is responsible for ascertaining, through his or her adviser and/or program office, the range of total activity of his or her individual program that constitutes normal progress toward the degree.

A student who is registered for a minimum of 9 credits is considered to be engaged in full-time academic work for that semester. Students who want to take more than 15 credits must be granted an exception on an individual basis through the Office of Graduate Student Programs. (See ACADEMIC CREDIT AND EMPLOYMENT, page 41.)

Graduate courses carry numbers from 500 to 599. Advanced undergraduate courses numbered between 400 and 499 may be used to meet some graduate degree requirements when taken by graduate students.

No student is permitted to count audited credits toward the minimum credit load for full-time or part-time status. Language courses used to meet foreign language requirements are exceptions, as are the SPCOM courses for international students.

Course-Numbering System — Courses in the series 1-399 are not listed in this bulletin because they are strictly undergraduate courses and yield no graduate credit. A graduate student may register for or audit these courses in order to make up deficiencies or to fill in gaps in previous education but not to meet requirements for an advanced degree.

Courses in the series 400-499 are for upperclass students with at least junior standing and for graduate students. Only a limited number of credits earned in these courses may be counted toward the requirements for an advanced degree. Detailed regulations concerning the restrictions are given on pages 53–59 under the specific requirements for the various master's degrees.

Courses in the series 500-599 are restricted to students registered in the Graduate School, senior undergraduate students with an average of at least 3.50, and certain other students with averages of at least 3.00 who have been granted special permission to enroll through the Office of Graduate Student Programs (see page 39).

The numbers 600 (on campus) and 610 (off campus) are available for credit in thesis research in all graduate major programs. The numbers 601 and 611 do not denote conventional courses but are used for noncredit special registration for thesis preparation by a Ph.D. candidate. (Note that 596 course numbers may *not* be used for thesis research work.) Registration under these numbers will maintain status as a student during the interval that begins at the time the student passes the comprehensive examination and meets the two-semester residence requirement and ends at the time the doctoral com-

mittee accepts the thesis. The student registers for 601 if engaged full time in the preparation of a thesis or for 611 if engaged only parttime in thesis preparation. Candidates for the Ph.D. degree do not receive grades for noncredit registrations (601 and 611) [see also p. 50].

Continuing Education Credits — A large number of courses carrying credit are given throughout the Commonwealth of Pennsylvania through continuing education. Some 400-series courses so offered *may* be used to meet graduate degree requirements when taken by students who have been admitted to the Graduate School. Approval by the student's adviser and program head is required.

Not more than 10 credits in 400-level courses earned through continuing education may be applied toward the minimum requirements for an advanced degree.

Schedule of Courses — A complete list of the courses that will be offered in any specific semester is given in the *Schedule of Classes*, which is available at nominal cost from the Scheduling Office approximately four months before the beginning of the semester. It gives the number of credits being offered in each course, the hours at which the class will meet, the location of the class, and in some cases the instructor's name.

Visiting and Auditing Classes — A graduate student registered for a given semester who wants to attend classes without receiving credit may secure permission either to visit or to audit courses during that semester.

As a visitor, a student may attend classes with the approval of the instructor but may not claim the usual privileges of class membership, such as participating in discussion, doing practicum work, or taking examinations. Registration is not required for the privilege of visiting, and no record appears on the student's transcript.

As an auditor, a student may participate in class discussion, do practicum work, take examinations, and generally enjoy the privileges of a class member. Registration procedures and fee payment are the same as for taking the course for credit. Attendance is required. No credit is given, either on completion of the course or at a later time; however, the number of credits assigned to the course appears on the grade report and on the student's transcript. Thus, when a student receives an audit grade, the number of credits audited is shown. The symbol AU shall be used if attendance has been regular, the symbol W if attendance has been unsatisfactory.

A graduate assistant or fellow who is required to register for a certain minimum number of credits is not permitted to count audited course credits toward the minimum credits needed. The special language courses are exceptions (see page 39). The student may register for credit or audit beyond the required minimum but may not exceed the normal maximum without special permission.

Common Courses — The following courses for which students may register have been set up for common use by major programs to encourage innovation and provide flexibility in designing graduate programs:

590. COLLOQUIUM (1-3) Continuing seminars which consist of a series of individual lectures by faculty, students, or outside speakers.

594. RESEARCH TOPICS (1-18) Supervised student activities on research projects identified on an individual or small group basis. A specific title may be used in each instance and will be entered on the student's transcript.

595. INTERNSHIP (1-18) Supervised off-campus, nongroup instruction, including field experiences, practicums, or internships. Written and oral critique of activity required. A specific title may be used in each instance and will be entered on the student's transcript. Prerequisite: prior approval of proposed assignment by instructor.

596. INDIVIDUAL STUDIES (1-9) Creative projects, including nonthesis research, which are supervised on an individual basis and which fall outside the scope of formal courses. A specific title may be used in each instance and will be entered on the student's transcript. Multiple offerings may be accommodated by the use of suffixes A, B, etc.

597. SPECIAL TOPICS (1-9) Formal courses given on a topical or special interest subject which may be offered infrequently; several different topics may be taught in one year or semester. A specific title may be used in each instance and will be entered on the student's transcript. Multiple offerings may be accommodated by the use of suffixes A, B, etc.

600, 610. THESIS RESEARCH — In registering for thesis research a student uses the appropriate number (600, 610) preceded by the abbreviation designating the major field. The numbers 600 (on campus) and 610 (off campus) are available for credit in thesis research in all graduate major programs. The bursar assesses charges for these courses at the current rate of tuition, according to the student's status at the time of registration.

601, 611. THESIS PREPARATION — The numbers 601 and 611 are available to Ph.D. degree candidates and may be used for special noncredit registration for thesis preparation work during its later stages, when the academic activity of the candidate consists solely of the completion of research and writing of the dissertation.
Such candidates must have passed the comprehensive examination and must have met the two-semester residence requirement (see page 47). A candidate registered for SUBJ. 601 is classified as a full-time student, while one registered for SUBJ. 611 is classified as a part-time student. (See Thesis Preparation, p. 43.)

The numbers 600, 601, 610, and 611 may not always appear in the *Schedule of Classes* for each semester.

602. SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-3 per semester, maximum of 6) May be offered by any graduate program in a department which also offers undergraduate courses. A graduate program with no counterpart undergraduate program may offer SUBJ. 602 when cooperative arrangements are made with an administrative unit which does not offer graduate degrees but which uses graduate assistants in its teaching. SUBJ. 602 may be offered in any semester and is subject to the following restrictions:

1. SUBJ. 602 shall not be counted in fulfilling any specific credit requirement for an advanced degree.
2. SUBJ. 602 shall be graded (A, B, C, D, F). The grade will appear on the student's transcript.
3. SUBJ. 602 shall not be used in calculating grade-point averages.
4. SUBJ. 602 shall be offered only in those graduate programs that want to provide opportunity for supervised and graded teaching experience. Enrollment shall be restricted to students for whom the major program is prepared to provide such experience.
5. SUBJ. 602 will be counted as a part of the student's credit load unless the program specifies otherwise.

ACADEMIC CREDIT AND EMPLOYMENT

To provide flexibility in arranging credit loads for graduate assistants and full-time University staff members, a procedure has been set up whereby the normal credit limits may be changed by permission of the person to whom the student or staff member is responsible for University employment or assistantship assignment, with the approval of the student's adviser. *Maintenance of the established credit loads and responsibility for consequences of a graduate student's change of course load rest with the student and adviser. The course load is a factor in determining whether a graduate student is classified as a full-time or part-time student; has met residence requirements; and is eligible to hold a fellowship, scholarship, assistantship, or departmental or program appointment.* Students holding fellowships, traineeships, or other awards based on academic excellence are required to carry 9 or more credits each semester.

A graduate student should achieve a balance among academic credit load, employment, and appointment responsibilities in order to be classified as a full-time graduate student with all the privileges and responsibilities intrinsic to this classification.

Full-Time Academic Status — A student who in any semester is registered for 9 or more credits *or* who holds a quarter-time assistantship and schedules 9 or more credits *or* who has a half-time assistantship and schedules 8 or more credits *or* who holds a three-quarter-time assistantship and schedules 6 or more credits *or* who is enrolled in SUBJ. 601 is considered by the Graduate School to be engaged in full-time academic work for that semester. A student who in any *summer session* is registered for 5 or more credits or who holds a quarter-time assistantship and schedules 5 to 7 credits or who has a half-time assistantship and schedules 4 to 6 credits or who holds a three-quarter-time assistantship and schedules 3 to 5 credits or who is enrolled in SUBJ 601 is considered full time.

Part-Time Academic Status — A student who in any semester is registered for fewer than 9 credits and does not hold a half-time or three-quarter-time assistantship is considered to be engaged in part-time academic work for that semester. Any student registered in any *summer session* for fewer than 5 credits and not holding a half-time or three-quarter-time assistantship is considered part time.

Full-Time Employment Off Campus — A candidate for the Ph.D. degree at a particular campus of the University may not count the work of any semester toward the residence requirement for this degree while engaged in full-time employment off campus or at a different campus of the University.

Benefits and Privileges — A student registered for 9 or more credits of course work *or* for noncredit SUBJ. 601 *or* who holds a half-time assistantship and is carrying at least 8 credits *or* who holds a three-quarter-time assistantship and is carrying at least 6 credits is entitled to the *nonacademic* student benefits and privileges of a full-time student.

Staff Employee Credit Status — A full-time staff employee of the University may schedule 6 credits per semester or 4 credits per eight-week summer session (up to 16 credits per academic year), either for credit or audit.

Full-time University employees may meet Ph.D. degree residence requirements by registering for the full number of credits allowable (6 credits per semester or 4 credits per eight-week summer session) and by obtaining certification from the department head as being principally engaged in activities directly relating to their degree objectives.

No member of the faculty in one of the professorial or professorial-equivalent ranks in the University may receive the master's degree or the doctoral degree from the University.

University staff employees who want to take graduate degree work must first be admitted to the Graduate School.

Employment — Many students depend upon part-time employment to help meet their expenses. A student who is thus employed, whether on or off campus, must recognize the time demands of a work schedule in planning an academic program. A student holding a fellowship or scholarship may not accept employment of any kind for service beyond that specifically permitted by the appointment. Graduate assistants may accept concurrent employment outside the University only after obtaining permission from the head of the department providing the assistantship and from the person in charge of the assistant's graduate program. A graduate assistant may not hold a concurrent appointment with the University other than a Fellowship Supplement.

GRADING SYSTEM

A grade is given solely on the basis of the instructor's judgment as to the student's scholarly attainment.

The following grading system is in effect: Any one of five quality grades (A,B,C,D,F) may be given a graduate student for course work or for thesis research. The grade-point equivalents are 4.00, 3.00, 2.00, 1.00, 0, respectively.

At the 400, 500, and 600 levels, grades of A, B, and C denote graduate credit, whereas D and F are failing grades for graduate students, D being the normal failing grade. A grade of F indicates doubt in the judgment of the instructor of the student's potential for further graduate study.

A minimum grade-point average of 3.00 for work done at the University is required for all graduate degrees.

In addition to the quality grades listed above, two symbols, DF (deferred) and R, may appear on a student's transcript. If work is incomplete at the end of a semester *for a reason beyond the student's control,* or if very little work remains to be done, the instructor may report DF in place of a grade, which will appear temporarily on the student's record. The deferral *must be removed within nine weeks of the beginning of the succeeding semester,* unless a special extension is granted by the senior associate dean. If the work is completed within the specified period of deferral and the instructor does not report a passing grade, the graduate recorder automatically records a failing grade. No student may be approved for a degree while a grade deferral or missing grade for a required course remains on the record. Deferred grade cards can be obtained from the graduate recorder, 112 Shields Building.

In the case of thesis work, either in progress or completed, and in certain courses (e.g., 590, 594, 595, 596, 597, and a few others) approved by the Graduate Council, the instructor may report the symbol R in place of a grade. An R does not influence the grade-point average. It indicates that the student has devoted adequate effort to the work scheduled but gives no indication of its quality. The symbol may be used, for instance, in courses that are officially designed to extend over more than one semester or in courses for which a quality grade is not appropriate. An R in an approved course need not be changed later to a quality grade, but may be changed if the instructor deems it appropriate when the course work has been completed. Normally, a quality grade must be reported no later than the end of the following semester.

When reported for thesis work, an R will not influence the grade-point average and remains on the student's transcript if not converted to a quality grade within one semester of its recording. The Graduate Council has established upper limits of 6 credits of quality grades for master's thesis research and 12 credits for doctoral thesis research. The remaining credits must be assigned Rs.

Pass-Fail (P/F) grading is used exclusively in certain graduate courses where it has been requested by the program and approved by the graduate dean following guidelines established by the Graduate Council. A grade of P does not influence the GPA, but an F does.

CONCURRENT CANDIDACIES

Occasionally, a candidate for an advanced degree in one major field wants to begin work for either a master's or a doctoral degree in a second field before completing the first program. The following procedures are to be followed in such cases:

1. To initiate concurrent candidacies in two major fields, the student should consult the department head or committee chair responsible for each field. If both approve, together they will draw up a program of study designed to meet the requirements of the two degrees. Any common agreements, such as the required completion of one program before advancing beyond a specified point in the other, should be added to the stated program of study as a part of the agreement before it is approved and signed by representatives of each field. Recommended guidelines can be obtained from the Office of Graduate Programs.
2. The signed agreement is submitted to the Office of Graduate Programs, 211 Kern Building, for review by the senior associate dean of the Graduate School. Upon approval, the student will be admitted to the new major field and will become concurrently a candidate in each field. The registrar's office will enter the new admission on the official records without terminating the first one. Either major (but not both) will be acceptable on the student's official registration form. The activation of the "intent to graduate" card in either field will be accepted at any appropriate time. When the preliminary check of records for graduation is made in the Office of Graduate Programs, the basic agreement will be reviewed to verify that all conditions have been met. Any revisions to the original agreement should be reported to the Office of Graduate Programs immediately.

Integrated Undergraduate–Graduate Study — The University Scholars Program offers selected baccalaureate degree candidates the opportunity to integrate undergraduate and graduate courses of study in a continuous program culminating in both a baccalaureate and a master's degree.

A University Scholar who is granted Integrated Undergraduate–Graduate (IUG) status will have dual enrollment in an undergraduate program and in the Graduate School. Some credits earned as an undergraduate may be applied to both degree programs. More information is available from the University Scholars Program Office.

CHANGE OF DEGREE OR PROGRAM

A graduate student who has been admitted for work in one major program but who wants to transfer to another should submit a request to the Office of Graduate Student Programs of the Graduate School. The student's credentials will be reviewed and the proposed new major department head or committee chair consulted. If the change is approved but the student is inadequately prepared for the new major, the student may be required to make up certain undergraduate deficiencies.

A graduate student admitted for either an academic degree (M.A., M.S., or Ph.D.) or a professional degree (M.Agr., M.B.A., M.E.P.C., M.Ed., M.Eng., M.F.A., M.F.R., M.H.A., M.L.A., M.Mus., M.P.A., M.Ps.Sc., M.Rc.Pk., or D.Ed.) who wants to change from one type of degree program to another must apply to the Office of Graduate Student Programs for the transfer. Similarly, a student who has earned a master's degree but who wants to earn a different type of doctoral degree must apply for a formal transfer. A student may be required to make up certain deficiencies if inadequately prepared for the new program.

Registration Near the Completion of a Program — A candidate for the Ph.D. degree is required to register continuously for each semester from the time the comprehensive examination is passed and the two-semester residence requirement is met until the thesis is accepted by the doctoral committee, regardless of whether work is being done on the thesis during this interval. (See REGISTRATION, page 39, and CONTINUOUS REGISTRATION, page 50.)

D.Ed. degree candidates and master's students may be required to register for a normal credit load because of their appointment status. A student, other than the Ph.D. degree candidate, who has met

the minimum requirements for a degree and is now completing research and thesis writing off campus is not required to register unless required to do so within the program. (See REGISTRATION, page 39.)

A master's or D.Ed. candidate is not required to register for the final semester in order to graduate or in order to make minor revision to the thesis and/or to take a final examination for the degree, unless required to do so by the program.

Thesis Research — In registering for thesis research a student uses the appropriate number (600, 610) preceded by the abbreviation designating the major field. The numbers 600 (on campus) and 610 (off campus) are available for credit in thesis research in all graduate major programs. The bursar assesses charges for these courses at the current rate of tuition according to the student's status at the time of registration.

Thesis Preparation — The numbers 601 and 611 are available to Ph.D. degree candidates and are used for special noncredit registration for thesis preparation work. Such candidates must have passed the comprehensive examination and must have met the two-semester residence requirement. A candidate registered for SUBJ. 601 is classified as a full-time student, while one registered for SUBJ. 611 is classified as a part-time student.

The numbers 600, 601, 610, and 611 may not always appear in the *Schedule of Classes* for each semester, but they are available for registration each semester.

GRADUATION

It is the responsibility of the student to inform the graduate recorder (at the Registrar's Office, 112 Shields Building) of the intention to graduate and to pay the thesis fee at the beginning of the semester or summer session in which an advanced degree is expected to be received. If the student does not graduate, the graduate recorder must be informed of the intention to graduate during the actual semester or summer session of graduation. Deadlines are given in the calendar found at the beginning of the *Graduate Bulletin.*

A preliminary graduation list is prepared by the graduate recorder soon after the deadline for each semester or summer session. Transcripts are prepared and checked in the offices of the Graduate School and the recorder. The records of candidates who appear to have met requirements are forwarded to major and minor department heads or program chairs for review and recommendation. The final list of approved candidates appears in the spring or summer commencement program.

Only those transfer credits that have been accepted by the Graduate School and entered upon the student's transcript by the recorder before the graduate list deadline will be considered in evaluating a student for graduation at the end of that particular semester or summer session.

The University holds commencement exercises for graduate students twice a year: at the end of the spring semester and at the end of the summer session. Attendance at commencement exercises is expected, but forms for permission to receive the degree in absentia are available in the Records Office, 112 Shields Building. The form must be completed and filed with the graduate recorder by the date specified in the graduate calendar.

All degrees conferred are tentative until final grade reports have been received and all requirements fulfilled, even though the student's name may have appeared in the commencement program. A student's transcript or diploma, or both, may be withheld until any outstanding financial obligations to the University have been paid.

UNSATISFACTORY SCHOLARSHIP

A graduate student who fails to maintain satisfactory scholarship or to make acceptable progress in a degree program will be dropped from the University. One or more failing grades or a cumulative grade-point average below 3.00 for any semester or session or combination of semesters and/or sessions may be considered as evidence of failure to maintain satisfactory scholarship. Action may be initiated by the department or committee in charge of the graduate major or by the chair of the student's doctoral committee.

MOTOR VEHICLE REGULATIONS

Each graduate student who possesses, maintains, or operates a motor vehicle (including a motorcycle, motor bike, motor scooter, or any other motor-driven vehicle) while at the University is required to register such vehicle with the Parking Office, 125 Grange Building, during the registration period at the opening of classes. There is no registration charge for students who do not want campus driving

or parking privileges. Failure to register a vehicle renders a student liable for a penalty of $20 or a magistrate's citation for each offense.

A permit allowing limited driving and parking on the campus throughout the week costs $15 per semester. A more restricted permit allowing driving and parking on the campus for evenings and weekends costs $6.00 per semester.

A graduate assistant is required to comply with student regulations concerning motor vehicles. A graduate assistant receiving any permit must present a valid driver's license and the owner's card for the vehicle. Pennsylvania registration of all motor vehicles is required if the student lives for more than thirty consecutive days of the year in Pennsylvania. A student's spouse may be required to register his or her car in Pennsylvania. A *Student Parking and Traffic Regulations* booklet is available in 125 Grange Building.

Bicycles — A bicycle is defined as a two-wheeled vehicle propelled by human power. All bicycles operated on the University Park Campus or in the surrounding community must be registered once each year. Expiration date is May 31. Registration can be obtained at the Department of University Safety, 12 Grange Building, or at any traffic kiosk, Monday through Friday between 8:00 a.m. and 5:00 p.m. Rules and regulations are available at the time of registration.

STANDARDS OF CONDUCT

By virtue of their maturity and experience, graduate students are expected to have learned the meaning and value of personal honesty and professional integrity before entering the Graduate School. Every student is expected to exhibit and promote the highest ethical and moral standards. A violation of such standards is regarded as a serious offense, raising grave doubt that the student is worthy of continued membership in the Graduate School community. Dishonesty or unethical conduct therefore may result in suspension or dismissal from the Graduate School.

PROTECTION OF HUMAN SUBJECTS

Any use of human subjects for research purposes must be reviewed and approved before their involvement in any way in research, instructional, and continuing education activities conducted under the auspices of the University.

The Office for the Protection of Human Subjects (OPHS) assists investigators, including graduate students, in obtaining review and approval of proposals for use of human research subjects. Use of human research subjects cannot be approved by thesis advisers or doctoral committees. The OPHS is part of the Office of the Vice President for Research and Dean of the Graduate School and manages protection of human subjects in investigations conducted at all campuses of the University, with the exception of the Milton S. Hershey Medical Center, which has its own administrative mechanism for protecting human subjects. Additional information and forms for presenting proposals for use of human subjects are available from the OPHS, 316 Kern Graduate Building, University Park Campus (telephone number: 814-865-1775; network number: 8-475-1775).

GRADUATE DEGREE REQUIREMENTS

DOCTORAL DEGREES

The Doctor of Philosophy, an academic degree, and the Doctor of Education, a professional degree, are conferred by the University. Recognized as different in purpose, the two programs consequently have different requirements in certain respects.

ADMISSION

A student who has been admitted to the Graduate School and has been accepted by the department or committee in charge of a major program in which the doctorate is offered may begin working toward a doctoral degree. However, the student has no official status as a doctoral student and no assurance of acceptance as a doctoral candidate until the candidacy examination has been passed. This examination is administered by the major department or graduate program and is given early in the student's program.

It is the policy of the Graduate School not to encourage applicants to work for a second doctoral degree. The President, on recommendation of the dean of the Graduate School, will welcome, as guests, holders of earned doctoral degrees who may be visiting the University Park Campus for purposes of noncredit study. Guest privileges apply to persons holding the degree from Penn State or other accredited colleges and universities. Guests may attend seminars and courses and, if space and facilities are available, carry on research. There will be no charge except for laboratory expenses. Arrangements should be made in advance with the dean of the Graduate School.

GENERAL REQUIREMENTS

No specified number of courses completed or credits earned will assure attainment of the doctorate. The general requirements are based upon a period of residence, the writing of a satisfactory thesis, and the passing of a comprehensive and a final oral examination. A doctoral program consists of such a combination of course seminars and individual study and research as meets the minimum requirements of the Graduate School and is approved by the doctoral committee for each individual student.

A master's degree is not a prerequisite for the doctorate in some major programs. However, the first year of graduate study leading to the Ph.D. may be substantially the same as that provided for the M.A. or M.S. degree. Similarly, the first year of the D.Ed. program may be essentially the same as that provided for the M.Ed. degree.

GRADE-POINT AVERAGE

A minimum grade-point average of 3.00 for work done at the University is required for doctoral candidacy, for admission to the comprehensive examination, and for graduation.

TIME LIMITATION

A student is required to complete the program within eight years from the date of acceptance as a candidate. Individual programs may set shorter time limits.

OFF-CAMPUS AND TRANSFER CREDITS

Subject to the approval of the adviser and the head of the major department or program chair, a student may register for research to be done away from the University Park Campus.

A maximum of 30 credits beyond the baccalaureate at an accredited school not granting the doctorate in the student's major program may be accepted by the Graduate School in partial fulfillment of the requirement for a doctoral degree at Penn State. A maximum of two full academic years of work (60 credits) beyond the baccalaureate at an accredited graduate school that grants the doctorate in the candidate's major program may be accepted here to apply toward doctoral degree requirements. Advanced standing is awarded for only one master's degree. Academic work to be so transferred must meet the following criteria: (1) It normally must have been completed within five years prior to the date of first degree registration at the Graduate School of Penn State (see below); (2) it must appear on an official graduate transcript; (3) it must be of at least B quality; and (4) it must be deemed applicable to the student's program by the current academic adviser, approved in writing, and submitted to the Graduate School assistant director of admissions for approval and action. Credit earned in postbaccalaureate professional degree programs (law, medicine, etc.) is not transferable.

The following caveat should be noted: Pass-fail grades are not transferable to an advanced degree program unless the "Pass" can be substantiated by the former institution as having at least B quality.

A *completed master's degree* may be transferred to a doctoral program with no intervening time limitation.

ADVISERS AND DOCTORAL COMMITTEES

Following admittance to a degree program, the student should confer with the head of that major department or program concerning procedures and the appointment of an adviser. Consultation or arrangement of the details of the student's semester-by-semester schedule is the function of the adviser. This person may be a member of the doctoral committee or someone else designated by the head of the major program for this specific duty.

General guidance of a doctoral candidate is the responsibility of a doctoral committee consisting of four or more active members of the Graduate Faculty, which normally includes at least three faculty in the major field. The committee chair and at least one other member of the committee must be senior members of the Graduate Faculty. At least one member shall be from outside the candidate's major program. If the candidate has a minor, that field must be represented on the committee. (See also

MAJOR PROGRAM AND MINOR FIELD *under* D.Ed. — ADDITIONAL SPECIFIC REQUIREMENTS.) This committee is appointed through the Office of Graduate Student Programs, upon recommendation of the head of the major program, after the student is admitted to candidacy. At the discretion of the senior associate dean, other members may be added to the committee. The supervisor of the candidate's thesis will usually, but not necessarily, be designated as chair. The chair must hold senior membership in the Graduate Faculty. An associate member may supervise the research of a doctoral candidate and serve as a co-chair of the committee.

The doctoral committee is responsible for establishing the broad outline of the student's program and should review the program as soon as possible after the student's admission to candidacy. The committee will prepare, give, and evaluate the candidate's examinations, and supervise and approve the thesis. A favorable vote of at least two-thirds of the members of the committee is required for passing a comprehensive or a final oral examination. If a candidate fails an examination, it is the responsibility of the doctoral committee to determine whether another examination may be taken.

The department or program head will also notify the senior associate dean when the candidate is ready to have the comprehensive and the final oral examinations scheduled and will report the results of these examinations to the Office of Graduate Student Programs.

COMMUNICATION AND FOREIGN LANGUAGE COMPETENCE

A candidate for the degree of Doctor of Philosophy is required to demonstrate high-level competence in the use of the English language, including reading, writing, listening, and speaking. Proficiency is expected at the time of admission to the Graduate School or must be achieved before admission to candidacy.

In addition to demonstrating competence in English, each candidate for the Ph.D. must meet any communication and foreign language requirements that have been established within the major program. The candidate should ascertain specific language requirements by contacting the professor in charge of the program, whose name appears with the program description under GRADUATE PROGRAMS, FACULTY, AND COURSES.

If a candidate is to be examined for knowledge of a foreign language other than French or Spanish, the intention to take the examination must be reported to the secretary of the language department by the end of the first week of classes for the semester during which the examination is to be taken. This date is one week prior to the examination date. This written examination will be administered on dates announced for each semester by the University Testing Services, 23 Willard Building, The Pennsylvania State University, University Park, PA 16802.

Penn State has been named by the Educational Testing Service as a testing center for the administration of the written tests for students to be examined in French or Spanish. Students who want to apply to take these tests should, at their earliest convenience, apply to the University Testing Services, 23 Willard Building, The Pennsylvania State University, University Park, PA 16802. A test fee of $12 is payable at the time of application. Times and places of tests will be given when the test application is filed.

Candidates for the Doctor of Education degree may be required to demonstrate competence in foreign languages.

CANDIDACY EXAMINATION

The candidacy examination is administered by the Graduate Faculty in the graduate major program and should be taken early in the student's program. The nature of the examination varies with the program and may be the master's examination if so allowed by the program. The decision to admit or not to admit a student to candidacy must be made by the Graduate Faculty or a designated committee of Graduate Faculty. For the Ph.D. student the examination may be given after at least 18 credits have been earned in graduate courses beyond the baccalaureate. The examination must be taken within three semesters (summer sessions do not count) of entry into the doctoral program.

The student must be registered as a full-time or part-time degree student for the semester in which the candidacy examination is taken.

For the D.Ed. student, the examination should be given when the student has earned a total of approximately 30 credits, including the master's program and work done elsewhere. A student transferring from another graduate school with 30 or more transfer credits must take the candidacy examination prior to earning more than 15 credits here.

COMPREHENSIVE EXAMINATION

When a candidate for the Ph.D. or D.Ed. degree has substantially completed the course work, a comprehensive examination covering the major program and minor field of study is required.

A candidate for the Ph.D. must have satisfied the communication and foreign language requirement before taking the examination.

All candidates are required to have a minimum grade-point average of 3.00 for work done at the University at the time the comprehensive examination is given.

The student must be registered as a full-time or part-time degree student for the semester in which the comprehensive examination is taken.

The examination is officially scheduled and announced by the senior associate dean upon recommendation of the department or program head. Two weeks' notice is required by the Graduate School for scheduling this examination. It is given and evaluated by the doctoral committee and may be *either written or oral, or both.* A favorable vote of at least two-thirds of the members of the committee is required for passing. In case of failure, it is the responsibility of the doctoral committee to determine whether the candidate may take another examination. The results are reported to the Office of Graduate Student Programs and will be entered on the candidate's official record.

When a period of more than six years has elapsed between the passing of the comprehensive examination and the completion of the program, the student is required to pass a second comprehensive examination before the final oral examination will be scheduled.

FINAL ORAL EXAMINATION

The doctoral candidate who has satisfied all other requirements for the degree will be scheduled by the senior associate dean, on the recommendation of the department or program head, to take a final examination. Two weeks' notice is required by the Graduate School for scheduling this examination. Normally the final oral examination may not be scheduled until at least three months have elapsed after the comprehensive examination was passed, although the senior associate dean may grant a waiver in the case of an outstanding student. The deadline for holding the examination is seven weeks before commencement. It is the responsibility of the doctoral candidate to provide a copy of the thesis to each member of the doctoral committee *at least one week* before the date of the scheduled examination.

Both the thesis director and the student are responsible for ensuring the completion of a draft of the thesis and for adequate consultation with members of the thesis committee *well in advance* of the oral examination. Major revisions to the thesis should be completed before this examination. *The dissertation should be in its final draft, with appropriate notes, bibliography, tables, etc., at the time of the oral examination; both the content and style should be correct and polished by the time this final draft of the thesis is in the hands of the committee.*

The final examination is oral, open to the public, and related in large part to the thesis, but it may cover the candidate's whole program of study without regard to courses that have been taken either here or elsewhere. The student must be registered as a full-time or part-time degree student for the semester in which the final oral examination is taken.

A favorable vote of at least two-thirds of the members of the committee is required for passing. The results of the examination are reported to the Office of Graduate Student Programs and will be entered upon the candidate's official record. If a candidate fails, it is the responsibility of the doctoral committee to determine whether another examination may be taken.

Ph.D. — ADDITIONAL SPECIFIC REQUIREMENTS

The degree of Doctor of Philosophy is conferred in recognition of high attainment and productive scholarship in some special field of learning as evidenced by (1) the satisfactory completion of a prescribed period of study and investigation; (2) the preparation of a thesis involving independent research; and (3) the successful passing of examinations covering both the special subject and the general field of learning of which this subject forms a part.

RESIDENCE REQUIREMENTS

There is no required minimum of credits or semesters of study, but over some twelve-month period during the interval between admission to candidacy and completion of the Ph.D. program the candidate must spend at *least two semesters* (which may include the semester in which the candidacy ex-

amination is taken) *as a registered full-time student* engaged in academic work at the University Park Campus, the Milton S. Hershey Medical Center, or Penn State Harrisburg. Full-time University employees must be certified by the department as devoting half-time or more to graduate studies and/or thesis research to meet the degree requirements. (See ACADEMIC CREDIT AND EMPLOYMENT, page 41.)

CONTINUOUS REGISTRATION

It is expected that all graduate students will be *properly registered* at a credit level appropriate to their degree of activity. (See REGISTRATION, page 39.) After a Ph.D. candidate has passed the comprehensive examination *and* met the two-semester full-time residence requirement, the student must register continuously for each fall and spring semester (beginning with the first semester after both of the above requirements have been met) until the Ph.D. thesis is accepted by the doctoral committee. (Note that students who are in residence (see page 38) during summers must also register for summer sessions.)

Post-comprehensive Ph.D. students can maintain registration by registering for credits in the usual way, or by registering for noncredit 601 or 611 (see pages 42 and 45), depending upon whether they are devoting full time or part time to thesis preparation. Students who want to combine course work with thesis preparation must register for 600 or 611 (i.e., not for 601, which is full-time thesis preparation). Note that the least expensive way for a student to work full time on research and thesis preparation is to register for 601. This clearly is the procedure of choice for international students who need to maintain status as full-time students for visa purposes.

If a Ph.D. student will not be in residence (see page 39) for an extended period for compelling reasons, the senior associate dean will consider a petition for a waiver of the continuous registration requirement. The petition must come from the doctoral committee chair and carry the endorsement of the department or program chair.

MINOR FIELD

A Ph.D. candidate is not required by the Graduate Faculty to have a minor field of study. However, a department or a committee in charge of a major field may require a candidate to offer work in a minor field, or a student may elect such a program with the permission of the doctoral committee.

A minor consists of no fewer than 15 credits, including those applied toward the master's degree (if the master's was awarded in a field other than the intended minor), of integrated or articulated work in one field related to, but different from, that of the major. A minor normally may be taken only in one of the approved graduate degree programs offered at Penn State, or in a formal graduate minor program that has been approved by the Graduate Council, such as the minor in the humanities or in literary theory, criticism, and aesthetics. The minor field chosen must have the approval of the departments or committees responsible for both the major program and the minor field.

THESIS

The ability to do independent research and competence in scholarly exposition must be demonstrated by the preparation of a thesis on some topic related to the major subject. It should represent a significant contribution to knowledge, be presented in a scholarly manner, reveal an ability on the part of the candidate to do independent research of high quality, and indicate considerable experience in using a variety of research techniques. The contents and conclusions of the thesis must be defended at the time of the final oral examination.

The completed thesis must be submitted to the Thesis Office by the announced submission deadline for the semester or summer session in which the degree will be conferred.

A *Thesis Guide,* which gives details concerning format, paper, typing, and other requirements, can be obtained at the Graduate School Thesis Office, 303 Kern Graduate Building, for a fee of $1.50. Following editorial review of the thesis by this office, it is expected that the student will submit a copy of the thesis, incorporating format corrections, to the office of the department or program head.

D.Ed. — ADDITIONAL SPECIFIC REQUIREMENTS

Programs leading to the degree of Doctor of Education are not limited to specific fields of education but, with the consent of the department or committee in charge and concurrence by the dean of the College of Education, may also be offered in any other field appropriate to the preparation of professional educators that has been approved for the doctorate.

The degree is conferred in recognition of advanced preparation of a high order for work in the profession of education as evidenced by (1) satisfactory completion of a prescribed period of study; (2) ability to apply scientific principles to practitioner problems in a variety of education endeavors; (3) preparation of a thesis demonstrating ability to undertake an educational problem with originality and independent thought; and (4) successful performance on major and minor examinations, showing a satisfactory grasp of the field of specialization and its relation to allied education areas.

RESIDENCE REQUIREMENTS

A minimum of six semesters of full-time graduate study and research (15 credits per semester), or their equivalent in credits (90 credits), of which at least 30 credits must be earned in residence at University Park, is required for the D.Ed. degree. The D.Ed. candidate may meet the requirements by attending summer sessions unless the major department requires a period of registration during the regular academic year. A candidate may register for a maximum of 30 credits of research in absentia, but none of these may count toward the minimum of 30 credits that must be earned at the University Park Campus. It is expected that students will register for a minimum of 15 credits of thesis research. The maximum credit load permitted a student who is employed full time is 6 credits per semester.

MAJOR PROGRAM AND MINOR FIELD

The program of study includes a major and either a minor or a group of general studies. A majority of the courses offered in fulfillment of the requirements must be in the major program of study.

A candidate choosing a major outside the fields of professional education (such as history) shall have a minor consisting of no fewer than 15 credits in professional education, including those applied toward a previous master's degree (if not in the same field as the minor), as recommended to the dean of the Graduate School early in the major program with the approval of a faculty adviser from the minor area.

A candidate choosing a major in one of the approved programs in professional education must also choose either a minor or a group of general studies with the approval of the major program chair. In this case, a minor consists of no fewer than 15 credits in a field considered by the major program committee to provide valuable intellectual and/or professional depth and breadth for the candidate. The minor may include courses taken as part of a previous master's degree program, if the minor is in an area different from the master's.

An acceptable general studies group consists of at least 15 credits, including those taken as part of a previous master's degree (up to 6 credits), considered by the major program committee to provide valuable intellectual breadth for the candidate. (Note that a general studies group is *not* a minor and is not entered as such on the student's transcript.)

A candidate entering with a master's degree in a field that would normally be regarded as appropriate for a minor may petition the major program committee for a waiver of the minor requirement. If the program chair then approves, a request for a waiver may be submitted by the chair to the senior associate dean of the Graduate School. Waiving the minor requirement does not reduce the residence or total credit requirements for the D.Ed. degree.

COMPREHENSIVE EXAMINATION

In addition to demonstrating a high level of competence in the subject matter in the major program and minor field, each candidate must show, by a comprehensive examination, an understanding of current theories of education and the ability to apply the techniques and findings of educational research so far as they bear upon the teaching of the subject matter. The candidate must also be able to understand and contribute to the technical and professional literature in the field, and to criticize learned procedures in the light of historical trends and practices in this and other countries. Command of the tools for a thorough study of the problems of education is necessary and must include competence in the use of statistical methods. For certain students the requirements may include a reading knowledge of one or more foreign languages.

All candidates are required to have a minimum grade-point average of 3.00 for academic work done at the University at the time the comprehensive examination is given.

THESIS

Evidence of a high degree of scholarship, competence in scholarly exposition, and ability to select, organize, and apply knowledge must be presented by the candidate in the form of a written thesis. The candidate must demonstrate a capacity for independent thought, as well as ability and originality

in the application of educational principles or in the development of a new generalization under scientific controls. A thesis may be based upon a product or project of a professional nature, provided scholarly research is involved. For example, it may be based upon the solution of a professional problem concerned with the development of a curriculum, or a product of creative effort related to education. However, in order to be acceptable as a thesis, the professional project must be accompanied by a written discourse demonstrating the nature of the research and including such theories, experiments, and other rational processes as were used in effecting the final result. The topic and outline of the proposed thesis must have the approval of the doctoral committee.

The completed thesis must be submitted to the Thesis Office by the announced submission deadline for the semester or summer session in which the degree will be conferred.

A *Thesis Guide,* which gives details concerning format, paper, typing, and other requirements, can be obtained at the Graduate School Thesis Office, 303 Kern Graduate Building, for a fee of $1.50. Following editorial review of the thesis by this office, it is expected that the student will submit a copy of the thesis, incorporating format corrections, to the office of the department or program head.

MASTER'S DEGREES

The Graduate School recognizes a difference in purpose, which is reflected in the requirements, for two types of advanced degrees: academic and professional. Of the sixteen master's degrees conferred, the Master of Arts and Master of Science are academic in nature. The professional degrees conferred are Master of Agriculture, Master of Business Administration, Master of Education, Master of Engineering, Master of Environmental Pollution Control, Master of Fine Arts, Master of Forest Resources, Master of Health Administration, Master of Landscape Architecture, Master of Management, Master of Music, Master of Psychosocial Science, Master of Public Administration, and Master of Recreation and Parks.

A degree is not conferred for a mere collection of credits. A well-balanced, unified, and complete program of study will be required, which may frequently exceed the minimum requirements as specified below under ADDITIONAL SPECIFIC REQUIREMENTS.

A student may meet the degree requirements by either full-time or part-time enrollment and by attendance in any combination of semesters and summer sessions. The student who interrupts the continuity of registration faces the possibility of not being granted permission to return.

GRADE-POINT AVERAGE

A minimum grade-point average of 3.00 for work done at the University is required for graduation.

TIME LIMITATION

All requirements for a master's degree, whether satisfied on the University Park Campus or elsewhere, must be met within eight years of admission to degree status. Individual programs may set shorter time limits.

ADMISSION

In addition to the general University requirements for admission set forth at the beginning of this bulletin, adequate undergraduate preparation is required in the program in which the applicant expects to pursue advanced work. The specific courses and the total number of undergraduate credits required in various areas will be determined by the choice of program and can be ascertained from the descriptive statement appearing under the graduate program heading in the latter portion of this bulletin. An applicant who meets the necessary grade-point average but is deficient in course preparation may, under certain circumstances, be admitted to the Graduate School and be allowed to make up the undergraduate deficiencies. Under these circumstances the program will require more than the necessary period of residence. An applicant for admission to the M.Ed. program in most major programs is required to have had at least 18 credits in education and related psychology, and in certain major programs may be required to have had practice teaching.

Requirements concerning courses, language proficiency, minors, comprehensive examinations, and other matters are sometimes made by departments or programs in addition to (but not in conflict with) the regulations of the Graduate School. For details the student should consult the head of the major department or program.

ADVISING

After admission to a degree program, a student should confer with the head of the major department or program concerning the appointment of an adviser. The general guidance of a master's candidate is the responsibility of an adviser, who is a member of the Graduate Faculty, or of a committee appointed in a manner to be determined by the major department or program in which the student is specializing. The adviser or the committee assists the student in planning a program of study. Although the adviser is frequently the supervisor of the thesis, this is not necessarily the case.

TRANSFER CREDIT

Subject to the limitations given, a maximum of 10 credits of high-quality graduate work done at an accredited institution may be applied toward the requirements for the master's degree. However, credits earned to complete a previous master's degree may not be applied to a second master's degree program at Penn State.

The student should distinguish carefully between the transferability of credit and its applicability in a particular degree program. Approval to apply any transferred credits toward a degree program must be granted by the student's academic adviser and the Graduate School assistant director of admissions. Transferred academic work normally must have been completed within five years prior to the date of first degree registration at the Graduate School of Penn State, must be of at least B quality, and must appear on a graduate transcript. Credit earned in postbaccalaureate professional degree programs (law, medicine, etc.) is not transferable.

Pass-fail grades are not transferable to an advanced degree program unless the "Pass" can be substantiated by the former institution as having at least B quality.

Forms for transfer of credit can be obtained from the Office of Graduate Admissions, 201 Kern Graduate Building.

EXAMINATIONS

A candidate may be required to pass in a satisfactory manner written or oral examinations designated by the program. A candidate should consult the major department or program for special requirements.

Examinations to establish credit for work done in absentia or without formal class work may be used to remove undergraduate deficiencies, but *not* to earn credits toward an advanced degree. Arrangements are made by the student directly with the major department head or program chair.

Graduate Record Examinations are designed to test information and abilities in basic fields of knowledge. These examinations are administered at scheduled times and convenient locations. Information can be obtained at the Graduate School Information Center on the first floor of Kern Graduate Building. (See also ADMISSION, page 34.)

M.A. and M.S. — ADDITIONAL SPECIFIC REQUIREMENTS

The Master of Arts and the Master of Science degrees have similar requirements, the general major area determining which degree is conferred. Programs for both degrees are strongly oriented toward research.

A minimum of 30 graduate credits is required, of which at least 20 must be earned at an established graduate campus of the University. Some graduate programs require additional credits; the exact number can be determined by consulting the specific program description in the subsequent section GRADUATE PROGRAMS, FACULTY, AND COURSES. A minor is not required of all candidates for the M.A. or M.S. degree. A department or committee in charge of a major program may require a candidate to offer work in a minor field, or the minor may be elected with the permission of the student's committee.

A minor consists of no fewer than 6 credits of integrated or articulated work in one field related to, but different from, that of the major. A minor program must be in one of the approved graduate degree programs offered at Penn State and must have the approval of the departments or committees responsible for both the major program and the minor field.

The major department or the committee in charge of the major program is the judge as to the suitability of a field for the minor and of its relevance to the major. The minor field department has the responsibility of accepting or rejecting students, advising on courses to be taken by the candidate in the field, examining the candidate in the area of studies undertaken in the field, and certifying that

the minor requirements have been met.

At least 18 credits in the 500 and 600 series, combined, must be included in the program. A minimum of 12 credits in course work (400 and 500 series), as contrasted with research, must be completed in the major program. A thesis is required of many candidates for these degrees. Details are given in the introductory paragraphs under the major program headings in the latter part of this bulletin. If a student is required to write a thesis, at least 6 credits in thesis research (600 or 610) must be included in the program. If no thesis is required, at least 18 credits must be in 500-level courses.

A thesis is prepared under the direction of the department or program in which the candidate's major work is taken. Under certain conditions a student may complete the thesis off campus. To do so, satisfactory arrangements must be made in advance with the adviser and the head of the major department or program.

Those candidates who are not required to write a thesis must present a suitable essay or paper. Its nature and extent shall be determined by the major program. The department head or program chair shall report to the Office of Graduate Student Programs the title, the name of the faculty member under whom the student did the work, and whether the work was considered adequate. The program head may require one or more copies of the essay for the program's library or other files.

Some programs in the field of education offer the M.S. degree but prefer to admit students into the M.Ed. degree program. Other programs that emphasize research prefer to admit only students interested in pursuing the Ph.D. degree.

Requirements for the M.A. degree at Penn State Harrisburg differ somewhat from the above and are outlined under the major programs in American Studies and Humanities. These programs are available only at Penn State Harrisburg.

A *Thesis Guide,* which gives details concerning format, paper, typing, and other requirements, can be obtained at the Graduate School Thesis Office, 303 Kern Graduate Building, for a fee of $1.50. Following editorial review of the thesis by this office, it is expected that the student will submit a copy of the thesis, incorporating format corrections, to the office of the department or program head.

M.Agr. — ADDITIONAL SPECIFIC REQUIREMENTS

The Master of Agriculture is a professional degree. Programs leading to this degree provide opportunities for students to increase their knowledge and competences in the various phases of agriculture. A student, according to individual objectives, may obtain intensive training encompassing a wide spectrum of subject matter area or intensive training in a specialized area. The emphasis of the program is to enable students to develop skills as professional practitioners in the communication of technical knowledge and its application to the solution of current and future technical, economic, and social problems of individuals and groups.

The head of the department or program chair shall appoint a three-member committee to guide and monitor the candidate's professional development. Members of this committee must represent at least two departments. The chair of the appointed committee shall serve as the candidate's adviser. The candidate will inform the committee of personal aspirations and background early in the program. The committee will suggest to the student how best to achieve these goals and the standard of professional competence required for the Master of Agriculture degree.

A minimum of 30 graduate credits is required, of which 20 credits must be earned in residence at the University Park Campus. A maximum of 10 credits may be earned in special problem-type courses.

Students in the Master of Agriculture degree program can major in Agricultural Economics, Agricultural Mechanization, Agronomy, Animal Science, Entomology, Extension Education, Fish and Wildlife Sciences, Forest Resources, Horticulture, Plant Pathology, or Rural Sociology.

The candidate must present an acceptable paper on a selected professional problem or a report of internship training. Up to 3 graduate credits will be given for an acceptable paper. The candidate may be required to provide one or more copies of the paper for the University.

The candidate's committee shall report, through the department head or program chair, to the Office of Graduate Student Programs the title of the paper and whether the paper and the candidate's academic performance were considered satisfactory.

M.B.A. — ADDITIONAL SPECIFIC REQUIREMENTS

Master of Business Administration degree programs are offered at the University Park Campus, Penn State Harrisburg, and Penn State-Behrend.

UNIVERSITY PARK CAMPUS

The purpose of the M.B.A. program at the University Park Campus is to develop professional managerial knowledge and skills as these are applied to decisions in complex organizations. The curriculum was developed by the graduate business faculty to blend technical rigor, managerial theory, and integrative learning experiences through case studies and other teaching methods.

A minimum of 54 graduate credits is required, all at the 500 level. Thirty-nine credits must be in specific core courses. Also required are 15 credits in major field courses and electives. Work for this degree may be started in the fall semester only. Applications must include the results of the Graduate Management Admission Test.

PENN STATE HARRISBURG, THE CAPITAL COLLEGE

The course of study leading to the M.B.A. degree is a professionally oriented program intended for persons seeking or holding management positions in business firms or in other technical and service organizations. The goals of the programs are to develop the following: competence in decision making; the ability to integrate and interrelate the various functions of the firm; an understanding of the environment in which the firm operates; skill in interpersonal and group relations; a sense of responsibility to society; and a commitment to ethical action within and outside the firm. The degree may be earned through either full- or part-time study in the evening.

The M.B.A. requires 54 credits of graduate course work consisting of three groups of courses. First, the common body of knowledge courses (33 credits) provide a foundation in the theory, tools, and techniques required for competent and ethical managerial decision making. Second, breadth courses (15 credits) provide advanced work beyond that required by the common body of knowledge courses and are aimed at developing a general competence in overall management. Preparation of a professional paper is required. Third, elective courses (6 credits) allow the candidate to select additional courses of interest. For more information, contact the Penn State Harrisburg Graduate Admissions Office at 717-948-6200.

PENN STATE ERIE, THE BEHREND COLLEGE

The M.B.A. program at Penn State-Behrend is designed for business professionals in northwestern Pennsylvania. To be effective managers, these professionals must be able to interpret information, analyze data both quantitatively and qualitatively, and select the appropriate tools for the tasks at hand. Penn State-Behrend's program seeks to develop the requisite skills through experience in confronting problems that require a grasp of both managerial theory and quantitative analysis for their resolution.

To earn the M.B.A. degree, students must complete satisfactorily twelve core courses (36 credits) and four elective courses (12 credits) for a total of 48 credits. A maximum of 10 credits may be transferred from another graduate institution. Either part-time or full-time study is possible. Applicants must submit the results of the Graduate Management Admissions Test.

M.Ed. — ADDITIONAL SPECIFIC REQUIREMENTS

The programs leading to the degree of Master of Education provide preparation for increased professional competence in education. They should be distinguished carefully from the research-oriented programs that lead to the academic degrees of Master of Arts or Master of Science. In most major programs the requirements for admission include 18 credits in education and related psychology.

A minimum of 30 graduate credits is required for the degree, of which at least 20 must be earned at an established graduate campus of the University; at least 24 must be in course work. This degree is also offered in certain programs at Penn State-Behrend, Penn State Harrisburg, and Penn State Great Valley.

MAJOR PROGRAMS IN THE FIELDS OF EDUCATION

A student can major in one of the approved programs in professional education (see DIRECTORY OF GRADUATE PROGRAMS AND DEGREES CONFERRED, pages 6 and 7) and proceed under the guidance of a graduate faculty member in the appropriate major. At least 12 of the required credits in course work must be taken at the 500 level.

A program of this type requires at least 6 credits to be earned outside the major in courses approved by the graduate faculty in the major as providing valuable breadth for the candidate.

MAJOR PROGRAMS OUTSIDE THE FIELDS OF EDUCATION

A student who wants to earn an M.Ed. in a specific subject-matter field, such as economics, mathematics, German, or a broader area, can choose such a program as a major and take a majority of work in it under the guidance of the department offering that major. The candidate is required to earn 6 credits in education as directed by the faculty of one of the approved graduate programs in professional education.

THESIS OR PAPER

Six credits may be granted for an approved thesis. A candidate who does not elect to write a thesis is required to present an essay or paper. It must be of considerable proportion, indicating capacity to describe a serious intellectual experience adequately in writing. It must also give unmistakable evidence of ability to formulate and state meaningfully the purpose of an investigation, study, critical analysis, or evaluation; to acquire and analyze information; to draw conclusions logically; and to relate findings to professional problems and practices. The nature and extent of this piece of writing, whether it be required in connection with a course or independent of course work, and when it is to be undertaken, shall be determined by the major program. The program chair shall report to the Office of Graduate Student Programs the title, the name of the faculty member under whom the student did the work, and whether the work was considered adequate. The program chair may exercise the option to require one or more copies of the essay for the program's library or other files.

M.Eng. — ADDITIONAL SPECIFIC REQUIREMENTS

The programs leading to the Master of Engineering degree provide training for advanced professional competence in several fields of engineering. They should be distinguished carefully from the research-oriented programs that lead to the academic degree of Master of Science.

A minimum of 30 graduate credits is required, of which 20 must be earned at an established graduate campus of the University. At least 12 credits must be earned in graduate courses (500 series).

A scholarly written report on a developmental study involving at least one area represented in the candidate's course work is required as an integral part of the program. The report must be comparable in its level of work and quality to a graduate thesis. The topic of the developmental study is subject to prior approval by the department in which the candidate's major work is taken, and preparation of the written report shall be under the direction of that department.

Work for this degree is not required to be done specifically at the University Park Campus. A complete program of study can be pursued at Penn State-Behrend, Penn State Harrisburg, or Penn State Great Valley.

M.E.P.C. — ADDITIONAL SPECIFIC REQUIREMENTS

The Master of Environmental Pollution Control is an intercollege professional degree designed for students who are interested in pursuing a career in the field of environmental pollution control. Special requirements include 9 credits of core courses covering air and water pollution control and solid waste management and participation in the environmental pollution control seminar program. A minimum of 30 graduate credits is required, 20 of which must be taken at either the University Park Campus or Penn State Harrisburg. Nine of these 30 credits must be taken at the 500 level; the E P C 590 seminars and any 500-level paper-writing courses may not be counted as part of this 9-credit requirement. A master's paper must be submitted by all M.E.P.C. candidates.

M.F.A. — ADDITIONAL SPECIFIC REQUIREMENTS

The programs leading to the Master of Fine Arts degree provide professional training in the several specialized areas of the arts. They should be distinguished carefully from the research-oriented programs that lead to the academic degree of Master of Arts with a major in art or theatre arts. The M.F.A. is widely accepted as the highest professional degree in art, creative writing, and theatre arts. The M.F.A. is a 48- to 60-credit degree, usually requiring three years to complete. Most of these credits should be earned on the University Park Campus.

The larger part of these credits should be above the 400 level, but the needs of the student shall be considered in arranging the best combination of courses and research for the preparation of the candidate in a particular field.

A professional creative project is required. This project shall include a monograph in support of the creative or interpretative aspect of the program.

M.F.R. — ADDITIONAL SPECIFIC REQUIREMENTS

The program leading to the Master of Forest Resources degree provides training for increased professional competence in the several specialized areas of forest resource management and forest products. It should be distinguished carefully from the research-oriented program that leads to the academic degree of Master of Science with a major in forest resources.

A minimum of 30 graduate credits is required, of which at least 20 must be earned at an established graduate campus of the University. At least 12 credits must be in courses at the 500 level, excluding F P 596, FOR 596, and WILDL 596. Also, 6 credits of statistics are required.

A candidate for the degree of Master of Forest Resources may elect a minor with the permission of the committee. A minor consists of no fewer than 6 credits of integrated work in one field related to, but different from, that of the major. A minor program must meet the approval of the department or committee responsible for the minor field.

Each candidate is required to submit an acceptable paper that demonstrates an ability to apply to the professional field the knowledge gained during his or her program. Six to 9 graduate credits will be given for this paper, which will be evaluated by the student's committee and defended in an oral examination.

M.H.A. — ADDITIONAL SPECIFIC REQUIREMENTS

The Master of Health Administration program is designed to prepare individuals for administrative positions in health services organizations. The curriculum combines a primary focus on health administration with additional content focusing on health and illness, health service organization and policy, and health services research.

A minimum of 51 credits is required for completion of the degree. Fifteen of these credits may be chosen from a group of supporting elective courses to emphasize a particular health services field and a particular administrative function. The M.H.A. degree requires the completion of a master's paper.

A maximum of 10 graduate credits may be transferred from another university. A waiver of up to 6 required credits may be approved for demonstrated competency in the subject matter area. Applicants must provide the scores from the Graduate Record Examination.

M.L.A. — ADDITIONAL SPECIFIC REQUIREMENTS

The Master of Landscape Architecture program provides opportunities for expanding professional competencies in the discipline. It enables young design professionals to specialize further and allows those with other educational backgrounds to focus their capabilities on environmental design.

A minimum of 46 credits is required for candidates with undergraduate degrees in landscape architecture. At least 36 of them must be earned at the University Park Campus. Twelve credits of graduate-level design studio are required, and the larger portion of the course work should be at the 500 level. Beyond these criteria, the goals of the individual student will determine the best combination of specific courses and research topics.

An individual project (a comprehensive design, professional paper, or formal thesis) is required. This project shall serve as the creative and/or interpretative capstone of the student's total academic program.

M.Mus. — ADDITIONAL SPECIFIC REQUIREMENTS

The program leading to the Master of Music degree provides training for increased professional competence in music. It should be distinguished carefully from the research-oriented program that leads to the academic degree of Master of Arts with a major in music history.

A minimum of 36 credits is required, of which 30 must be earned at the University Park Campus. At least one-half of the required credits must be at the 500 level.

Depending on the major option, a professional project in performance, conducting, or composition is required. Also required are a master's paper and a comprehensive examination.

M.Ps.Sc. — ADDITIONAL SPECIFIC REQUIREMENTS

The graduate program in Psychosocial Science at Penn State Harrisburg leads to a Master of Psychosocial Science degree, with a major in Community Psychology. This is a nontraditional degree program that emphasizes experience in carrying out a master's project. The program is concerned with equipping students with some of the skills necessary to cope with the multifaceted problems facing communities. Students learn to recognize problems, to outline and implement possible solutions to these problems, and to evaluate the effectiveness of the solutions.

To perform these functions, the student must be aware of contemporary community needs, the impact of the community structure upon its individual members, and the techniques best suited to initiate productive changes. After completing this interdisciplinary program, the graduate should be able to approach problems with a more integrated point of view and work cooperatively with community individuals and agencies toward practical solutions. Problems in drug abuse, delinquency, unemployment, housing, and other areas affecting mental health are approached from a community service agency base or from less formal community groups dealing with the same problems. At present, approximately 90 percent of all students work full time in agencies or governmental units. To accommodate them, most graduate 500-level courses are scheduled in the evening.

The program requires 37 credits, with 24 credits at the 500 level.

M.P.A. — ADDITIONAL SPECIFIC REQUIREMENTS

The Master of Public Administration is a professional degree for students who are planning careers in public administration in local, state, and national governmental jurisdictions or in international, private, or voluntary agencies. The M.P.A. degree is offered at the University Park Campus and Penn State Harrisburg.

The M.P.A. degree offered at the University Park Campus requires a minimum of 30 graduate credits, of which 24 must be earned at the University Park Campus. The greater portion of the courses must be at the 500 level. An M.P.A. research paper also is required and carries graduate credit.

The M.P.A. degree offered at Penn State Harrisburg requires a minimum of 45 graduate credits including a 9-credit field study (internship) experience and a professional master's project. The 9-credit field study requirement may be waived for students who have at least three years of full-time professional experience in relevant administrative or staff work. There is no comprehensive final examination.

The program leading to the Master of Public Administration degree should be distinguished from the research-oriented program that leads to the academic degree of Master of Arts with a major in political science, in which the candidate may specialize in public administration.

M.Rc.Pk. — ADDITIONAL SPECIFIC REQUIREMENTS

The program leading to the professional Master of Recreation and Parks degree offered at Penn State Harrisburg is designed to improve competency in leisure service management skills, program development, and evaluation. It should be distinguished from the research-oriented program that leads to the academic degree of Master of Science in Recreation and Parks. The M.Rc.Pk. program is offered in a nontraditional format, permitting students to pursue their studies while continuing to work full time in a leisure-based agency.

A minimum of 30 credits is required, of which 18 form the general core of courses in the major. Additional course work is required for specialization in one of three areas: park and recreation management, therapeutic recreation, or commercial recreation/tourism. Each candidate is required to submit an acceptable paper demonstrating the ability to identify and analyze an important problem or issue affecting a leisure service organization and develop alternatives based upon the problem-solving skills acquired in the program.

PENNSYLVANIA DEPARTMENT OF EDUCATION CERTIFICATE CANDIDATES

Postbaccalaureate candidates for all Level I Instructional, Supervisory, Educational Specialist, and Administrative certificates issued by the Pennsylvania Department of Education upon the recommendation of the University must be admitted to Penn State as degree or certificate graduate students. Graduate students who want to pursue a Level I certificate in conjunction with an advanced degree must contact the office of Certification and Education Services (181 Chambers Building, 814-865-0488) in addition to submitting an application to the Graduate School. The credentials for certification-only students will be forwarded by the Office of Certification and Education Services to the Graduate School.

All Level I certification candidates are advised that a Precertification Competency Examination must be completed prior to issuance of a certificate. This examination samples the knowledge base needed by teachers and other educators in order to educate the handicapped in the least restrictive environment. The examination is individually administered usually during the semester preceding the candidate's internship or major practicum. Information on preparing for the examination is available from graduate faculty advisers or the Office of Certification and Education Services in 181 Chambers Building. There is no charge for the first trial.

Postbaccalauerate candidates who want to pursue course work simply for their professional development and/or a permanent Level II certificate should apply to the Graduate School as special nondegree graduate students.

GRADUATE PROGRAMS, FACULTY, AND COURSES

ACOUSTICS (ACS)

JIRI TICHY, *Chair of the Committee on Acoustics*
Applied Research Laboratory, Applied Science Building
814-865-6364

Degrees Conferred: Ph.D., M.S., M.Eng.

Senior Members of the Graduate Faculty
Carter L. Ackerman, Ph.D. (Penn State) *Associate Professor of Engineering Research*
John L. Brown, Jr., Ph.D. (Brown) *Professor of Electrical Engineering*
Sabih I. Hayek, D.Eng.Sc. (Columbia) *Professor of Engineering Mechanics*
L. Raymond Hettche, Ph.D. (Carnegie-Mellon) *Professor of Engineering Research*
Gerald C. Lauchle, Ph.D. (Penn State) *Senior Scientist, Applied Research Laboratory; Professor of Acoustics*
Julian D. Maynard, Ph.D. (Princeton) *Associate Professor of Physics*
Suzanne T. McDaniel, Ph.D. (Penn State) *Senior Scientist, Applied Research Laboratory; Professor of Acoustics*
Vernon H. Neubert, D.Eng. (Yale) *Professor of Engineering Mechanics*
Gerhard Reethof, Sc.D. (MIT) *Professor of Mechanical Engineering*
Leon H. Sibul, Ph.D. (Penn State) *Senior Scientist, Applied Research Laboratory; Professor of Acoustics*
Eugen J. Skudrzyk, Ph.D. (Berlin) *Professor Emeritus of Physics*
Richard Stern, Ph.D. (UCLA) *Senior Scientist, Applied Research Laboratory; Professor of Applied Science and Mechanics*
William Thompson, Jr., Ph.D. (Penn State) *Professor of Engineering Science*
Jiri Tichy, D.Sc. (Prague Inst. of Tech.) *Professor of Architectural Engineering*
Vasundara V. Varadan, Ph.D. (Illinois) *Associate Professor of Engineering Science and Mechanics*
Vijay K. Varadan, Ph.D. (Northwestern) *Professor of Engineering Science and Mechanics*

Associate Members of the Graduate Faculty
John H. Beebe, Ph.D. (Penn State) *Research Associate, Applied Research Laboratory*
Courtney B. Burroughs, Ph.D. (Catholic) *Research Associate, Applied Research Laboratory; Assistant Professor of Acoustics*
W. Jack Hughes, Ph.D. (Penn State) *Research Associate, Applied Research Laboratory; Assistant Professor of Acoustics*
Claus P. Janota, Ph.D. (Penn State) *Research Associate, Applied Research Laboratory; Assistant Professor of Acoustics*
Roger L. Kerlin, Ph.D. (Penn State) *Research Associate, Applied Research Laboratory*
John A. Macaluso, Ph.D. (Penn State) *Assistant Professor of Engineering Research*
Robert D. Marciniak, Ph.D. (Penn State) *Research Associate, Applied Research Laboratory*
Diana F. McCammon, Ph.D. (Penn State) *Research Associate, Applied Research Laboratory; Assistant Professor of Acoustics*
Oliver H. McDaniel, Ph.D. (Penn State) *Research Associate, Applied Research Laboratory; Assistant Professor of Acoustics*
Francis R. Menotti, Ph.D. (Connecticut) *Research Associate, Applied Research Laboratory*
James H. Prout, M.S. (Michigan) *Associate Professor of Engineering Research*
Dennis W. Ricker, Ph.D. (Purdue) *Senior Research Associate, Applied Research Laboratory; Associate Professor of Acoustics*
Alan D. Stuart, Ph.D. (Penn State) *Senior Research Associate, Applied Research Laboratory; Associate Professor of Acoustics*

The aim of this intercollege program is to enable the student interested in acoustics to obtain an integrated program of courses covering the fundamentals of acoustical science and the biological, communications, and engineering applications of acoustics.

Programs are arranged through a selection of appropriate courses offered by several departments in the Colleges of Earth and Mineral Sciences, Engineering, Health and Human Development, Liberal Arts, and Science, as well as those specifically in the area of acoustics.

Areas of concentration include acoustic signal processing, architectural and building acoustics, noise and vibration, physical acoustics, speech and hearing, and underwater acoustics. Thesis re-

search in the various areas may be conducted in acoustical laboratories which are located throughout the campus and are administered separately by the departments to which they are connected. These laboratories are the Applied Research Laboratory, the Physical Acoustics Laboratory, the Noise Control Laboratory, the Shock and Vibration Laboratory, the Architectural Acoustics Laboratory, the Environmental Acoustics Laboratory, and the Speech Laboratory.

Admission Requirements

Scores from the Graduate Record Examination (GRE) are encouraged, but not required, for admission. Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin*.

Entering students should hold a bachelor's degree in physics, biology, engineering, architecture, mathematics, psychology, speech and hearing, or in a closely related field; they should have had at least one year of physics and mathematics including integral calculus. Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

Doctoral Degree Requirements

The communication and foreign language requirement for the Ph.D. degree may be satisfied by competence in the use of computer language, as well as a reading knowledge of a foreign language.

Other Relevant Information

In addition to the acoustics courses listed below, the following courses on acoustics and closely related areas are available: AERSP 444, 506, 511; A E 458, 542; CMDIS 430, 515, 522, 531, 532, 533, 534, 535, 572, 573; E E 459, 530, 560, 561, 562; E MCH 412, 516, 521, 522, 524A,B,C, 525, 527, 528, 560, 562, 570, 597B; GPHYS 507A,B; METEO 435, 527, 536, 551; M E 458, 554; PHYS 443, 533; SPCOM 413, 520.

Student Aid

Graduate assistantships available to students in this program and other forms of student aid are described in the STUDENT AID section of the *Graduate Bulletin*.

ACOUSTICS (ACS)*

401. General Acoustics (3)
402. Introduction to Acoustics (3)
403. Modern Electronics for Engineering Acoustic Applications (3)
496. Independent Studies (1-18)
497. Special Topics (1-9)

510. Fundamentals of Acoustics (5) In-depth presentation of the fundamental principles of acoustics; designed to prepare students to take advanced courses in acoustics.

511. Underwater Sound Propagation (3) Theoretical and empirical treatment of sound propagation in the ocean, including effects of the environment, characteristics of targets, and transducers.

512. Sonar Engineering (3) Theoretical and empirical treatment of problems related to the use of underwater sound in target detection and ranging.

513. Digital Signal Processing (3) Discrete linear systems, transforms, digital filter design and applications, discrete Fourier transforms, spectrum analysis.

*A course abbreviation, a number, and a title designate each course. Course designations and official abbreviations are listed above the first course in each group. The figures in parentheses following the course title show the number of credits which may be granted for that course. In the case of courses with variable credits, the number of credits which may be earned in a single semester is determined by the department or program offering the course.

A department or major program may schedule an entire section of a course below the 400 level for fewer credits than the maximum authorized. In 400- and 500-series courses, an individual student may schedule fewer credits than the maximum number but in no case more than the maximum number authorized.

All courses listed under graduate majors may not be required in the particular major.

514. Electroacoustic Transducers (3) The theory, design, and calibration of passive, linear, reciprocal electroacoustic transducers for use in both air and water media. Prerequisite: PHYS 443 or ACS 510.

515. Acoustics in Fluid Media (3) Wave propagation in stationary and moving fluids; acoustic radiation and scattering; standing waves in ducts and cavities. Prerequisites: E MCH 524A; PHYS 443 or ACS 510.

516. Acoustical Data Measurement and Analysis (3) Presents the engineering applications of recent developments in correlation and spectral analysis to acoustical measurement problems.

517. Techniques for Solving Acoustic Field Problems (3) Transient and time-harmonic acoustic radiation and scattering problems involving various boundary conditions, solved by exact, approximate, and numerical methods. Prerequisites: ACS 515, E MCH 524B.

518. Adaptive Signal Processing (3) Basic concepts and application of adaptive signal processing techniques; adaptive filters, beamformers; optimum space/time processors and their adaptive implementation; adaptive algorithms. Prerequisites: E E 562; E E 459 or MATH (STAT) 409.

590. Colloquium (1-3)

596. Individual Studies (1-9)

597. Special Topics (1-9)

ADMINISTRATION OF JUSTICE (ADM J)

DANIEL KATKIN, *in charge*
159S Henderson Building South
814-863-0078

Degrees Conferred: Ph.D., M.A.

Senior Members of the Graduate Faculty
Thomas J. Bernard, Ph.D. (SUNY-Albany) *Associate Professor of Administration of Justice*
Alan A. Block, Ph.D. (UCLA) *Professor of Administration of Justice*
Bruce H. Bullington, Ph.D. (UCLA) *Associate Professor of Criminal Justice*
Walter E. Freeman, Ph.D. (Michigan State) *Professor of Administration of Justice*
Daniel E. Georges-Abeyie, Ph.D. (Syracuse) *Associate Professor of Administration of Justice*
Lynne Goodstein, Ph.D. (CUNY) *Associate Professor of Administration of Justice*
John Philip Jenkins, Ph.D. (Cambridge-England) *Associate Professor of Criminal Justice*
Daniel Katkin, J.D. (Columbia) *Professor of Law*
John H. Kramer, Ph.D. (Iowa) *Associate Professor of Criminal Justice and Sociology*
Stephen D. Mastrofski, Ph.D. (North Carolina-Chapel Hill) *Assistant Professor of Administration of Justice*
Arthur H. Patterson, Ph.D. (Northwestern) *Associate Professor of Administration of Justice*
R. Richard Ritti, Ph.D. (Cornell) *Professor of Administration and Sociology*

Associate Member of the Graduate Faculty
William F. Walsh, Ph.D. (Fordham) *Assistant Professor of Administration of Justice*

Admission Requirements
Scores of the Graduate Record Examination (GRE) are required for admission. Candidates also must have superior undergraduate or graduate grade-point averages and either advanced undergraduate training in criminology at the 400 level or completion of SOC 406 or 511 or equivalent.

Master's Degree Requirements
The core component (9 credits) of the program, which provides a comprehensive overview of the discipline, consists of three 3-credit courses in administration of justice. These courses correspond to the three areas of concentration in the program — organizations and institutions, policy and law, and criminal enterprise — and will help students to decide upon a subsequent area of specialization.

In addition, the core program also requires 6 credits in research design and methods, with one 500-level course in research design and methods and one 500-level course in applied statistics.

Students will be required to select 15 credits in an area of concentration as described above. Each area consists of four 3-credit courses and ADM J 540, Seminar in Criminal Justice Policy, which will focus on current faculty research and be offered on a rotating basis in consecutive semesters, drawing on work in each of the areas of concentration in turn.

After completing the 30 credits described above, the candidate takes the departmental examination, which covers material from the core component and the candidate's selected area of concentration. Candidates will also be required to complete a master's paper.

Doctoral Degree Requirements

Students who enter with a bachelor's degree and who want to pursue a doctoral degree in the field will be admitted to candidacy following completion of the master's requirements described above. Students admitted with a master's degree will be required to stand for a candidacy examination at the completion of the first semester of full-time study.

The department's communication and foreign language requirement may be satisfied in one of the following ways: (1) fluency in one foreign language; (2) proficiency in an applied computer language and statistical analysis (the former fulfilled by completing an applied data analysis project and the latter by a 500-level course in applied statistics); (3) reading proficiency in two foreign languages as established by the ability to read and translate criminal justice materials in those languages.

Doctoral candidates will be required to complete one additional course in methods or statistics beyond the master's degree requirements. Also, candidates must complete ADM J 509, Criminal Justice Policy Research (6 credits).

Each doctoral student, together with his or her advisory committee, must arrange for a structured, individualized sequence of courses (15 credits) to provide a foundation in social, behavioral, or political science. This sequence may include business, economics, psychology, political science, public administration, or sociology, but may be taken in any field that supports the student's educational objectives. This sequence will be selected in the student's second year of study.

Doctoral candidates who have substantially completed their course work will take the comprehensive examination as described in the *Graduate Bulletin*. Candidates are expected to be proficient in three fields: the justice system generally and their area of concentration in particular; their chosen emphasis in social, behavioral, or political science; and statistics and methodology. This examination will be both written and oral. The candidate is also required to submit his or her completed dissertation for a final oral examination as described in the *Graduate Bulletin*.

Student Aid

Graduate assistantships available to students in this program and other forms of student aid are described in the STUDENT AID section of the *Graduate Bulletin*.

ADMINISTRATION OF JUSTICE (ADM J)

401. Probation, Parole, and Pardons (3)
410. Correctional Counseling Processes (3)
420. Special Offender Types (3-6)
421. Violent Crime in the United States (3)
422. Victimless Crimes and the Administration of Justice (3)
425. Law Enforcement Responses to Organized Crime (3)
430. Correctional Institutions and Services (3)
440. Fundamental Techniques of Scientific Criminal Investigation (3)
441. The Juvenile Justice System (3)
445. (COM S 445) Criminal Justice and the Community (3)
451. Minorities and the Criminal Justice System (3)
460. History and Function of Criminal Justice Components (3)
462. Comparative Criminal Justice Systems (3)
470. Law of Crimes and Corrections (3)
471. (B LAW 471) Legal Rights, Duties, Liabilities of Criminal Justice Personnel (3)
472. Crime and the American Court System (3)
473. (B LAW 473) Criminal Procedure and Evidence in the Business Community (3)
482. Seminar, Criminal Justice Agency Administration (3)
485. Policing in America (3)
496. Independent Studies (1-18)
497. Special Topics (1-9)

501. Criminal Justice Organizations and Institutions (3) Organizations and institutions involved in the formulation and implementation of criminal justice policy in complex social and organizational environments.

502. Development of Criminal Justice Policy and the Legal Environment (3) Development of criminal justice policy during the nineteenth and twentieth centuries and the corresponding evolution of the legal environment.

503. Justice Policy and Criminal Enterprise (3) The structure of criminal enterprise and policy issues relevant to controlling criminal enterprises.

509. Criminal Justice Policy Research Methods (3 per consecutive semester, maximum of 6) Application of social research methods to criminal justice policy issues, with focus on individual research projects. Prerequisites: SOC 513, 574.

510. Justice Policy and Environmental Crime (3) Criminalization of various types of environmental pollution and resulting problems and strategies in enforcement. Prerequisite: ADM J 503.

511. Regulation of Corporate and Governmental Crime (3) The developing role of criminal law in the regulation of corrupt or illegal activity in corporations and government agencies. Prerequisite: ADM J 503.

520. Reform Issues in Justice Policy (3) Reforms in criminal justice systems, with an emphasis on bureaucratic dynamics. Prerequisite: ADM J 502.

530. Juvenile Justice Systems and Policies (3) State and national juvenile justice systems: the sources and consequences of the present diversity. Prerequisite: ADM J 501.

540. Seminar in Criminal Justice Policy (3) Current developments in criminal justice policy with reference to criminal enterprise, the legal environment, and administration of the justice system. Prerequisite: ADM J 501 or 502 or 503.

554. Evaluating Criminal Justice Policy (3) An examination of criteria and measures for evaluating criminal justice policies and the impact of various policies. Prerequisites: ADM J 501, 502, 503.

596. Individual Studies (1-9)

597. Special Topics (1-9)

602. Supervised Experience in College Teaching (1-3 per semester, maximum of 6)

ADULT EDUCATION (ADTED)

PETER S. COOKSON, *In Charge of Graduate Programs in Adult Education*
222 Rackley Building
814-863-3781

Degrees Conferred: D.Ed., M.Ed.

Senior Members of the Graduate Faculty
Eunice N. Askov, Ph.D. (Wisconsin) *Professor of Education*
Peter S. Cookson, Ph.D. (Chicago) *Associate Professor of Education*
Sebastian Martorana, Ph.D. (Chicago) *Professor of Education*
Michael G. Moore, Ph.D. (Wisconsin) *Associate Professor of Education*
David L. Passmore, Ph.D. (Minnesota) *Professor of Education*
William Toombs, Ph.D. (Michigan) *Professor of Education*
Susan F. Weis, Ph.D. (Penn State) *Associate Professor of Education*

Associate Members of the Graduate Faculty
Joe F. Donaldson, Ph.D. (Wisconsin) *Associate Professor of Education*
Donna S. Queeney, Ph.D. (Penn State) *Affiliate Associate Professor of Education*
Jovita M. Ross, Ed.D. (Georgia) *Assistant Professor of Education*
Joan S. Thomson, Ph.D. (Wisconsin) *Affiliate Assistant Professor of Education*

The central focus of a program of studies leading to a degree in Adult Education is the facilitation of purposeful continuing learning by men and women — alone, in groups, in the community, or in institutional settings. Adult Education extends through the life span from late adolescence to advanced age and takes place in a rich diversity of organizational as well as informal settings. The purpose of the Adult Education program is to increase the knowledge and competence of those who work with

adult learners. Course work, reading assignments, projects, internships, informal discussions, and the dissertation all provide opportunities for in-depth, mind-stretching, and challenging learning experiences. The programs are interdisciplinary, and students are advised to seek learning beyond the minor in supporting fields within the University.

The Adult Education program is designed for each student, taking into consideration differences in life experience, including education, work, family situation, and plans for future employment. Typically, people interested in Adult Education are engaged in or oriented toward careers as researchers, administrators, counselors, instructors, and program planners in learning environments such as community development, staff development, professional continuing education, corrections education, literacy and adult basic education, religious education, human services, correspondence/distance learning, higher education, and university extension.

Scheduling is arranged, so far as possible, to accommodate the employed student, although full-time study is recommended. Entering students are expected to have a concept of their major interest and possible thesis subject, which may be developed during course work.

Admission Requirements

Scores from the Graduate Record Examination (GRE), or from the Miller Analogies Test (MAT), are required for admission. At the discretion of a graduate program, a student may be admitted provisionally for graduate study in the program without these scores. Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin*.

The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Applicants with a total Verbal and Quantitative score above 1100 on the GRE, a junior-senior average of 3.00, and a graduate average of 3.50 are usually admitted to the D.Ed. program. Applicants with a junior-senior average of 2.70, a graduate average of 3.20, and a GRE total score of 1000 but with special backgrounds, abilities, and interests also may be admitted to the doctoral program with only the baccalaureate degree, but they will earn the master's degree en route. The Miller Analogies Test may be accepted in place of the GRE for admission to the graduate program in Adult Education. A sample of serious student writing and a "career letter" in which applicants explain how the proposed studies in adult education relate to their career are required for each degree.

Master's Degree Requirements

M.Ed. students are required to write a master's paper in lieu of a thesis, in addition to the required 33 credits of course work. A minimum of 18 credits in course work must be taken at the 500 level, with at least 15 of those 18 credits being in Adult Education courses.

Doctoral Degree Requirements

D.Ed. students who do not have previous experience in adult education are expected to acquire the equivalent of one year of experience prior to receiving their D.Ed. degree. During the comprehensive examination, in addition to being examined in their area of specialization, all D.Ed. students will be examined in the common adult education areas: history and philosophy; curriculum, advising, and instruction; organization and administration; adult education clientele; and research methodology.

Student Aid

Graduate assistantships available to students in this program and other forms of student aid are described in the STUDENT AID section of the *Graduate Bulletin*.

ADULT EDUCATION (ADTED)

460. Introduction to Adult Education (3)
496. Independent Studies (1-18)
497. Special Topics (1-9)

505. The Teaching of Adults (3) Examination of direct and indirect teaching; contracts, application of current technology, andragogy, motivation, evaluation; knowledge of research. Prerequisite: ADTED 460.

506. Program Planning in Adult Education (3) Intensive study of theoretical foundations, policies, evaluation models, methods, and materials in program planning in adult education. Prerequisites: ADTED 460, 505.

507. Research and Evaluation in Adult Education (3) Guided discussion and reading in selected research and evaluation methods and trends as applied in adult education settings. Prerequisites: ADTED 460; introductory statistics course; introductory research design course.

510. Historical and Social Issues in Adult Education (3) Social and historical foundations of adult education in the United States and selected nations. Prerequisite: ADTED 460.

549. (HI ED 549) Community Junior College and the Technical Institute (2-3) Distinctive contributions to meeting the need for postsecondary education; development, functions, curriculum and instruction, government, administration, and finance.

560. (RCLED 560) Teaching Reading to College Students and Adults (3) Reading/literacy for adults, including college reading, Adult Basic Education (ABE), and General Educational Development (GED) programs. Prerequisite: RCLED 440 or teaching experience.

570. International Adult Education (3) Survey of adult education theory and practice outside North America, including international agency involvement. Prerequisite: ADTED 460.

575. (EDADM 575) Administration of Adult Education (3) Organization of a program of adult education; legal status, finances, selection of teachers, learning personnel, housing; other administrative problems. Prerequisite: EDADM 480 or teaching or administrative or supervisory experience.

588. Professional Seminar: Research and Adult Education (3) Review of research in adult education, current and past, with analysis of its directions, effects, methodology, quality, financing, and prospects. Prerequisites: ADTED 460, 507.

595. Internship in Adult Education (3-9) Supervised student internship in adult education agency. Prerequisite: ADTED 460.

596. Individual Studies (1-9)

597. Special Topics (1-9)

AEROSPACE ENGINEERING (AERSP)

DENNIS K. MCLAUGHLIN, *Head of the Department*
233 Hammond Building
814-865-2569

Degrees Conferred: Ph.D., M.S.

Senior Members of the Graduate Faculty
Steven Deutsch, Ph.D. (Penn State) *Senior Research Associate; Professor of Aerospace Engineering*
George S. Dulikravich, Ph.D. (Cornell) *Associate Professor of Aerospace Engineering*
J. William Holl, Ph.D. (Penn State) *Professor of Aerospace Engineering*
Budugur Lakshminarayana, Ph.D., D.Eng. (Liverpool) *Evan Pugh Professor of Aerospace Engineering*
Barnes W. McCormick, Jr., Ph.D. (Penn State), P.E. *Boeing Professor of Aerospace Engineering*
Philip J. Morris, Ph.D. (Southampton) *Associate Professor of Aerospace Engineering*
Blaine R. Parkin, Ph.D. (California Tech.), P.E. *Professor of Aerospace Engineering*
William G. Pritchard, Ph.D. (Cambridge) *Professor of Aerospace Engineering*

Associate Members of the Graduate Faculty
Shaaban A. Abdallah, Ph.D. (Cincinnati) *Research Associate*
Michael L. Billet, Ph.D. (Penn State) *Senior Scientist*
Cengiz Camci, Ph.D. (Von Karman Inst.) *Assistant Professor of Aerospace Engineering*
Gilbert H. Hoffman, Ph.D. (Stanford) *Senior Research Associate*
David W. Jensen, Ph.D. (MIT) *Assistant Professor of Aerospace Engineering*
Mark D. Maughmer, Ph.D. (Illinois) *Assistant Professor of Aerospace Engineering*
Robert G. Melton, Ph.D. (Virginia) *Associate Professor of Aerospace Engineering*
Michael M. Micci, Ph.D. (Princeton) *Assistant Professor of Aerospace Engineering*
Hubert C. Smith, Ph.D. (Virginia) *Assistant Professor of Aerospace Engineering*
Donald E. Thompson, Ph.D. (Penn State) *Senior Research Associate*

Opportunities for graduate study are available in the following areas: low-speed aerodynamics, V/STOL aircraft, turbulence, astrodynamics, turbomachinery, aeroacoustics, gas dynamics, hydrodynamics, stability and control of aerospace vehicles, aeroelasticity, aerospace structures, astronautics, computational fluid dynamics, space propulsion, and space vehicle dynamics.

Admission Requirements

Scores from the Graduate Record Examination (GRE) are not required for admission to the graduate program. If a student is applying for financial assistance, however, it is highly desirable that applicants submit GRE scores. Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin*.

The entering M.S. student must hold a bachelor's degree in physical science, mathematics, or engineering, and may be required to complete (without degree credit) undergraduate course work in fluid and solid mechanics and intermediate mathematical analysis, if not already completed. Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission to the M.S. program. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests. The best-qualified applicants will be accepted up to the number of spaces that are now available to new students. Satisfactory completion of a master's program in physical science, mathematics, or engineering is required for admission to the Ph.D. program.

M.S. and Ph.D. Core Requirements

1. Two courses for 6 credits in basic field theories, one in each of two different categories from a prescribed list in fluid mechanics, solid mechanics, or particle dynamics.
2. One 3-credit course from a prescribed list in numerical or computational methods for analysis of differential equations.
3. One 3-credit course from a prescribed list of 500-level applied mathematics courses.
4. Graduate students must demonstrate proficiency in technical writing skills.
5. Graduate students must demonstrate evidence of experimental experience.

Master of Science Degree Requirements

A total of 30 credits is required. This includes courses in the core requirements. Twelve credits must be in aerospace engineering courses with at least 9 credits at the 500 level. A student may take a maximum of 6 credits of 400-level course work. Six credits of thesis research are also required. Completion of an M.S. thesis is required for graduation.

Doctoral Degree Requirements

There is no foreign language requirement for the Ph.D. degree. However, students must satisfy the technical writing requirement in the core requirements and must demonstrate high-level competence in the use of the English language. Ph.D. course requirements in addition to those specified in the core requirements are decided by the candidate's doctoral committee on an individual basis.

The following examinations are administered by the committee during the progression of the Ph.D. program. The candidacy examination is given as a preliminary aptitude test before the end of the second semester. A comprehensive examination covering the major and minor fields of study is administered after the candidate has substantially completed the required course work. The final oral examination, which is related mainly to the thesis, is given after the candidate has satisfied all of his or her degree requirements.

Continuous registration is required of all Ph.D. graduate students until the thesis is approved.

Student Aid

In addition to the fellowships, traineeships, graduate assistantships, and other forms of financial aid described in the STUDENT AID section of the *Graduate Bulletin,* the following awards typically have been available to graduate students in this program:

AMELIA EARHART FELLOWSHIP — Available to a woman graduate student in aerospace engineering; stipend $5,000.

W. S. ELLIOTT FELLOWSHIP — Available to a graduate student who is a graduate of Penn State and is interested in engineering research; stipend variable. Apply to Office of the Dean, College of Engineering, 101 Hammond Building.

TAU BETA PI FELLOWSHIP — Open to any member of Tau Beta Pi, the engineering honor society, for a year of advanced study. Up to eighteen awards of $3,500 each are available. Applications and information can be obtained from the Office of the Dean, College of Engineering, 101 Hammond Building. Application deadline is February 15.

NASA Traineeships — Available to B.S. graduates in engineering, physical sciences, mathematics, and computer science pursuing graduate studies in computational fluid dynamics. Applications and information can be obtained from Dr. Philip J. Morris, 153 Hammond Building.

AEROSPACE ENGINEERING (AERSP)

401A. Spacecraft Design — Preliminary (2)
401B. Spacecraft Design — Detailed (2)
402A. Aircraft Design — Preliminary (2)
402B. Aircraft Design — Detailed (2)
403. Design of Air Transport Systems (3)
405. Aerodynamics Laboratory (2)
406. Structures and Dynamics Laboratory (2)
407. Aerodynamics of V/STOL Aircraft (3)
410. Aerospace Propulsion (3)
411. Aeroelasticity (3)
412. Turbulent Flow (3)
413. Stability and Control of Aircraft (3)
415. Physical Gas Dynamics (3-6)
416. Aerospace Professional Activities (1)
420. Principles of Flight Testing (3)
421. (M E 421) Intermediate Viscous Flow (3)
423. Introduction to Numerical Methods in Fluid Dynamics (3)
425. Theory of Flight (3)
430. Space Propulsion and Power Systems (3)
444. Introduction to Aeroacoustics (3)
450. Orbit and Attitude Control of Spacecraft (3)
490. (E E 490, NUC E 490) Introduction to Plasmas (3)
492. (ASTRO 492, E E 492) Space Astronomy and Introduction to Space Science (3)
494. Aerospace Undergraduate Thesis (1-3 per semester, maximum of 6)
496. Independent Studies (1-18)
497. Special Topics (1-9)

504. Aerodynamics of V/STOL Aircraft (3) Jet wings, high lift devices, propellers and ducted propellers, circulation and boundary layer control, unsteady airfoil theory. Prerequisite: AERSP 407.

505. Aero- and Hydroelasticity (3) Interaction of elastic systems having several degrees of freedom with fluid flows in various configurations.

506. Cavitation (3) Flow regimes, dynamics of cavitation, prediction of the minimum pressure in the fluid, scale effects, effect of surface irregularities.

507. Theory and Design of Turbomachinery (3) Theory and principles of machinery design: compressors, turbines, pumps, and rotating propulsors; opportunity to work out design examples.

508. Foundations of Fluid Mechanics (3) Mathematical review, fluid properties, kinematics, conservation laws, constitutive relations, similarity principles, the boundary layer, inviscid flow, vorticity dynamics, wave motion.

509. Dynamics of Ideal Fluids (3) Irrotational flow theory, two-dimensional and axisymmetric flows, airfoil theory, complex variables, unsteady phenomena; flow with vorticity, finite wing theory. Prerequisite: AERSP 508.

510. Compressible Flow (3) Classification and solution of compressible flow problems, high-speed gasdynamics, unsteady motion, transonic and hypersonic flows, atmospheric reentry.

511. Aerodynamically Induced Noise (3) Review of fluid mechanics. General theory of aerodynamic sound. Noise radiation from jets, boundary layers, rotors, and fans. Structural response.

512. Viscous Flow (3) Stress-deformation relations; Newtonian fluids, Navier-Stokes equations; exact, asymptotic laminar solutions; instability, transition; similitude and turbulent boundary layer.

514. Stability of Laminar Flows (3) The stability of laminar motions in various geometries as influenced by boundary conditions and body forces of various kinds.

515. Statistical Theories of Turbulence (3) Statistical analysis of random scalar and vector fields. Homogeneous turbulence: similarity, correlation, and spectral descriptions; spectral transfer; production and dissipation.

517. Inhomogeneous Turbulence (3) Flow instability and transition; descriptions of structural hypotheses and energy budgets for classical flows; closure models; role of turbulence measurements.

518. Dynamics and Control of Aerospace Vehicles (3) Dynamical problems of aircraft and missiles, including launch, trajectory, optimization, orbiting, reentry, stability and control, and automatic control. Prerequisite: AERSP 413 or 450.

526. (M E 526) Computational Methods for Shear Layers (3) Study of numerical solution methods for steady and unsteady laminar or turbulent boundary-layer equations in two and three dimensions. Prerequisite: AERSP 423 or M E 540.

527. (M E 527) Computational Methods in Transonic Flow (3) Numerical solution of partial differential equations of mixed type, with emphasis on transonic flows and separating boundary layers. Prerequisite: AERSP 423 or M E 540.

528. (M E 528) Computational Methods for Recirculating Flows (3) Numerical solution techniques for laminar/turbulent flow with large recirculation zones. Both primitive variable and stream function-vorticity equations used. Prerequisites: AERSP 423, M E 540.

529. Advanced Analysis and Computation of Turbomachinery Flows (3) Review of numerical methods; three-dimensional inviscid flow computation, two- and three-dimensional viscous flow effects and computation; recent advances. Prerequisites: AERSP 423; AERSP 507 or M E 418.

540. (E E 540, NUC E 540) Theory of Plasma Waves (3) Solutions of the Boltzmann equation; waves in bounded and unbounded plasmas; radiation and scattering from plasmas. Prerequisite: AERSP (E E, NUC E) 490.

550. Astrodynamics (3) Applications of classical celestial mechanics to space flight planning. Determination and construction of orbital parameters by approximation methods. Perturbation techniques. Prerequisite: AERSP 450 or ASTRO 460 or E MCH 410 or PHYS 419.

590. Colloquium (1-3)

596. Individual Studies (1-9)

597. Special Topics (1-9)

602. Supervised Experience in College Teaching (1-3 per semester, maximum of 6)

AGRICULTURAL ECONOMICS (AG EC)

DONALD M. CRIDER, *Interim Head of the Department of Agricultural Economics and Rural Sociology*
6 Weaver Building
814-865-5461

Degrees Conferred: Ph.D., M.S., M.Agr.

Senior Members of the Graduate Faculty
James G. Beierlein, Ph.D. (Purdue) *Associate Professor of Agricultural Economics*
James W. Dunn, Ph.D. (Oklahoma State) *Associate Professor of Agricultural Economics*
Donald J. Epp, Ph.D. (Michigan State) *Professor of Agricultural Economics*
Milton C. Hallberg, Ph.D. (Iowa State) *Professor of Agricultural Economics*
Robert O. Herrmann, Ph.D. (Michigan State) *Professor of Agricultural Economics*
Robert F. Hutton, Ph.D. (Harvard) *Professor of Farm Management*
J. Dean Jansma, Ph.D. (Oklahoma State) *Professor of Agricultural Economics*
J. Patrick Madden, Ph.D. (Iowa State) *Professor of Agricultural Economics*
John W. Malone, Jr., Ph.D. (Oklahoma State) *Professor of Agricultural Economics*
Robert H. McAlexander, Ph.D. (Iowa State) *Professor of Farm Management*
Earl J. Partenheimer, Ph.D. (Michigan State) *Professor of Agricultural Economics*
Wayne A. Schutjer, Ph.D. (Michigan State) *Professor of Agricultural Economics*
Robert D. Weaver, Ph.D. (Wisconsin) *Associate Professor of Agricultural Economics*

Associate Members of the Graduate Faculty
Theodore R. Alter, Ph.D. (Michigan State) *Associate Professor of Agricultural Economics*
Jill F. Findeis, Ph.D. (Washington State) *Assistant Professor of Agricultural Economics*
William Gillis, Ph.D. (Wisconsin) *Assistant Professor of Agricultural Economics*
Frank M. Goode, Ph.D. (Minnesota) *Associate Professor of Agricultural Economics*
William L. Henson, Ph.D. (Penn State) *Adjunct Assistant Professor of Agricultural Economics and Rural Sociology*
James Shortle, Ph.D. (Iowa State) *Assistant Professor of Agricultural Economics*
Blair J. Smith, Ph.D. (North Carolina State) *Associate Professor of Agricultural Economics*
Spiro Stefanou, Ph.D. (California-Davis) *Assistant Professor of Agricultural Economics*

The graduate program emphasizes economic theory and analytical techniques in the fields of farm management, production economics, agricultural marketing, resource economics, rural development, agricultural policy and prices, and international agricultural trade and development.

Admission Requirements
Scores from the Graduate Record Examination (GRE), or from a comparable substitute examination accepted by a graduate program and authorized by the dean of the Graduate School, are required for admission. At the discretion of a graduate program, a student may be admitted provisionally for graduate study in a program without these scores. Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin*.

Students entering the master's program should have a total of 9 credits in agricultural economics and/or economics. Students entering the doctoral program should have successfully completed courses in intermediate micro- and macroeconomic theory, in differential and integral calculus and linear algebra, and in intermediate statistics. Students are permitted to enter the master's and doctoral programs with deficiencies but must pass courses to eliminate deficiencies as soon as possible.

Students with a 2.75 junior-senior grade-point average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.75 grade-point average may be made for students with special backgrounds, abilities, and interests.

Doctoral Degree Requirements
There is no foreign language requirement for the Ph.D. degree; rather, the student must satisfactorily complete courses in economic theory and quantitative methods.

Other Relevant Information
Students in this program may elect the dual-title degree program option in Operations Research for the Ph.D. and M.S. degrees (see p. 326).

Students may qualify for admission to the dual-title degree program option in Demography consisting of interdisciplinary course work, with special emphasis on the economic, social, and geographic issues arising from the dynamics of population change.

Student Aid
Graduate assistantships available to students in this program and other forms of student aid are described in the STUDENT AID section of the *Graduate Bulletin*.

AGRICULTURAL ECONOMICS (AG EC)

401. Land and Water Resource Policy (3) *Epp*
402. Land and Water Resource Economics (3) *Epp*
403. Rural Community Development (3)
407. Farm Planning and Financial Management (3)
410. Agricultural Real Estate Appraisal (3) *Gingrich*
420. Agricultural Prices (3) *B. Smith*
450. Agriculture and International Economic Development (3) *S. Smith*
460. Economics of the Food Industry (3) *Malone*
461. Managerial Economics in Agricultural Business Firms (3) *Beierlein*
462. Economics of Public Policy in Agriculture (3)
480. Planning Agricultural Programs in Less Developed Countries (1)
495. Internship in Agribusiness and Rural Development (1-3)

496. Independent Studies (1-18)
497. Special Topics (1-9)
499. Foreign Study—Agricultural Economics (1-12)

501. Agricultural Production Economics I (3) Application of microeconomic theory to problems and decisions of farm households and agricultural firms. Prerequisite: ECON 502. *Madden*

502. Economics of Natural Resources and Rural Development (3) Emphasis will be placed on the application of economic concepts to problems and policies in rural areas. Prerequisites: ECON 502, 503. *Goode*

503. Agricultural Marketing (3) Economic analysis of food marketing firms and institutions; identification and measurement of dimensions of market performance; public policy. Prerequisite: ECON 502. *Hamlett*

510. (ECON 510) Econometrics I (3) General linear model, multicolinearity, specification error, autocorrelation, heteroskedasticity, restricted least squares, functional form, dummy variables, limited dependent variables. Prerequisite: ECON 490 or STAT 462 or 501. *Stefanou*

511. (ECON 511) Econometrics II (3) Stochastic regressors, distributed lag models, pooling cross-section and time-series data, simultaneous equation models. Prerequisite: AG EC (ECON) 510. *Weaver*

517. Resource Economics and Rural Development (3) Present, apply, and empirically implement the concepts used for analyzing resource and rural development problems. Prerequisites: ECON 502, 503. *Goode*

518. Process of Rural Policy Development (3) Study of the concepts and applications of the process by which public policy evolves. Prerequisites: ECON 502, 503.

519. Economic Analysis of Land and Water Resource Policy (3) History and analysis of natural resource policies, including U.S. public land disposal, conservation, and environmental protection policies. Selected current topics. Prerequisites: ECON 502, AG EC 517, 518. *Shortle*

520. Application of Microeconomics in Agriculture (3) Applications of microeconomic theory in agriculture. Prerequisite: ECON 521. *Hallberg*

525. Research Methods in Rural Social Sciences (3) Scientific method in planning and conducting research. Prerequisites: 9 credits in social sciences. *Stokes*

527. Quantitative Methods I (3) Quantitative techniques applied to agricultural economic issues. Prerequisite: ECON 502. *Findeis*

528. Quantitative Methods II (3) Advanced topics in quantitative techniques applied to agricultural economic issues. Prerequisite: AG EC 527. *Findeis*

533. Rural Development Research Methods and Topics (3) Advanced theories and methods for rural economic development research. Prerequisites: AG EC 502, 511, ECON 521. *S. Smith*

534. Agricultural Production Economics II (3) Current problems and methods of analysis in production economics research. Prerequisites: AG EC 511, 527, ECON 521. *Musser*

535. Dynamic Production Theory (3) The analysis of dynamic production decision processes within deterministic and stochastic settings; cost of adjustment and sequential decision models. Prerequisites: AG EC 527, ECON 511, 521. *Stefanou*

536. Agricultural Commodity Markets (3) Specification, identification, and estimation of models for use in the evaluation and control of agricultural market behavior. Prerequisite: AG EC (ECON) 510 or 511 or ECON 521. *Weaver*

537. Agricultural Marketing: Theory and Methods (3) Economic analysis of food and agricultural markets; spatial economics of agriculture; industrial organization of agricultural markets. Prerequisites: AG EC 503, 511, 527, ECON 521. *Hamlett*

538. Policy for the Food and Agriculture Sector (3) Policy formation; policies for food and agriculture, consequences for farmers, consumers, resources; farm program benefits and costs; current issues. Prerequisites: AG EC (ECON) 511, ECON 521, 522. *Hallberg*

541. Resource and Environmental Economics (3) Key theories and analytical methods of resource and environmental economics. Prerequisites: AG EC 511, 519, ECON 521. *Shortle*

542. Land and Water Resource Economics (3) Selected topics to expand understanding of major economic concepts used in analysis of current natural resource problems. Prerequisites: AG EC 511, 517, ECON 521; AG EC 401 or 402 or 502. *Epp*

543. Rural Economic Development Theories (3) Discussion of the state-of-the-art in rural economic development research. Prerequisites: AG EC 517, 518, ECON 521, 522. *Goode*

550. International Economic Development and Agriculture (3) The economic development process with particular emphasis on agriculture. Prerequisite: ECON 502. *Abler*

589. (ECON 589) Seminar in Econometric Theory (3) Theories and methods relevant to the application of statistical methods to economics. Prerequisite: AG EC (ECON) 510.

590. Colloquium (1-3) Continuing seminars which consist of a series of individual lectures by faculty, students, or outside speakers.

596. Individual Studies (1-9)

597. Special Topics (1-9)

602. Supervised Experience in College Teaching (1-3 per semester, maximum of 6)

AGRICULTURAL EDUCATION (AG ED)

SAMUEL M. CURTIS, *Head of the Department*
102 Armsby Building
814-865-1688

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Senior Members of the Graduate Faculty
Samuel M. Curtis, D.Ed. (Penn State) *Professor of Agricultural Education*
Cordell Hatch, Ph.D. (Wisconsin) *Professor of Agricultural and Extension Education*
Anne L. Heinsohn, Ph.D. (Penn State) *Associate Professor of Extension Education*
Gene M. Love, Ph.D. (Penn State) *Professor of Agricultural Education*
James H. Mortensen, Ph.D. (Penn State) *Associate Professor of Agricultural Education*
Jerry H. Reyburn, Ph.D. (Purdue) *Professor of Agricultural and Extension Education*
Dennis C. Scanlon, Ph.D. (Ohio State) *Assistant Professor of Agricultural Education*
Richard F. Stinson, Ph.D. (Ohio State) *Professor of Agricultural Education and Horticulture*
Edgar P. Yoder, Ph.D. (Ohio State) *Associate Professor of Agricultural Education*

Associate Members of the Graduate Faculty
Connie D. Baggett, Ph.D. (Penn State) *Assistant Professor of Agricultural Education*
Phyllis A. Barner, Ph.D. (Oklahoma State) *Assistant Professor of Agricultural and Extension Education*
M. Joy Cantrell, Ph.D. (Mississippi State) *Assistant Professor of Agricultural and Extension Education*
Barbara W. Daws, Ph.D. (Penn State) *Assistant Professor of Agricultural and Extension Education*
James E. Diamond, Ph.D. (Penn State) *Assistant Professor of Agricultural and Extension Education*
Donald E. Evan, D.Ed. (Penn State) *Associate Professor of Agricultural and Extension Education*
Robert B. Lewis, Ed.D. (North Carolina State) *Professor of Agricultural and Extension Education*
William Williams, Ph.D. (Penn State) *Associate Professor of Agricultural Education*

Graduate programs emphasize the professional improvement of teachers and extension personnel with education responsibilities. These programs provide advanced preparation for employment in administration, supervision, teaching (including teacher education), and research in agricultural education and related fields. A minor may be taken in an area of the student's choice or in general studies. Programs may include courses needed for certification in other fields of education.

Admission Requirements
Scores from the Graduate Record Examination (GRE) must be submitted and are considered in the admission decision. Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin.*

Prerequisite for admission to a master's program is a minimum of 18 credits in professional education courses — including educational psychology and student teaching — or certification as a teacher of agriculture or equivalent professional experience, including extension. Students with a 2.50 junior-senior average and with appropriate course background will be considered for admission to the

M.S. or M.Ed. program. Admission to a doctoral program requires a 3.00 grade-point average for graduate work. Applicants to the doctoral program must submit evidence of ability to write a scholarly paper or thesis and demonstrate a teaching-level competence in English. The best-qualified applicants for all degrees will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum grade-point averages may be made for students with special backgrounds, abilities, and interests. Applicants for the master's degree must submit an essay, two or three typewritten pages in length, that describes their background, work experience, education, and career goals in pursuing a master's degree. All advanced degree candidates must submit three letters of recommendation.

Master's Degree Requirements

A contractual agreement between adviser and student, including planned course work and time frame, must be completed before beginning the second semester of study. Successful performance on a four-hour written essay exam, plus a one-hour oral exam, is required of all M.S. and M.Ed. candidates near the completion of their course work for the degree. The master's candidate also is required to successfully complete an oral defense of a paper or thesis.

A minimum of two years of successful public, private, or extension teaching experience is required before the master's degree is completed.

Doctoral Degree Requirements

There are no foreign language requirements for the D.Ed. or Ph.D. in Agricultural Education; however, ENGL 418 and SPCOM 312, or equivalent communication courses, are required.

A minimum of two years of successful public, private, or extension teaching experience is required before the doctoral degree is completed.

Other Relevant Information

Selection and appointment of a thesis adviser and doctoral committee follow admission to candidacy. The candidate consults the department head in selecting an adviser. The candidate, in cooperation with an adviser, selects the doctoral committee. The chair of the committee is not necessarily the thesis adviser, but the thesis adviser is a member of the committee.

Student Aid

Graduate assistantships available through this program and other forms of student aid are described in the STUDENT AID section of the *Graduate Bulletin*.

AGRICULTURAL EDUCATION (AG ED)

400. Educational Programs in Agriculture for Developing Countries (3)
412. Methods of Teaching Agriculture (4)
413. Advanced Methodology in Agricultural Education (2)
418. Survey of Vocational Education in Agriculture (1-4)
420. Instructional Media in Agriculture (1-6)
424. Occupational Guidance in Agricultural Industry (1-4)
426. Adult Education in Agriculture (1-4)
434. Agricultural Developments (1-6)
440. (EXTED 440) Communication Methods and Media (3)
450. (EXTED 450) Methodology of Extension Education (3)
490. Colloquium (1-3)
495. Student Teaching in Agriculture (1-15)
496. Independent Studies (1-8)
497. Special Topics (1-9)

501. Agricultural Education in the United States (1-3) Historical development, social and philosophical foundations, and current status in relation to the total vocational-technical education program.

502. Teaching Agriculture (1-3) Vocational education objectives, learning theory, class instruction, cooperative occupational experience, and evaluation.

507. Administration and Supervision of Agricultural Education I (1-2) Basics of vocational funding, supervision, leadership, and management for agricultural education. Prerequisite: previous experience in agricultural education or vocational education.

508. Administration and Supervision of Agricultural Education II (1-2) Basics of vocational funding, supervision, leadership, and management for agricultural education.

509. Teacher Education in Agriculture (1-6) Organization and administration of university programs of teacher education in agriculture, including preservice preparation, continuing education, research, and other services.

520. Scientific Method in the Study of Agricultural Education (1-4) Methods of procedure in investigation and experimentation in education, accompanied by a critical examination of studies made in agricultural education.

521. Scientific Method in the Study of Agricultural Education (1-4) Continuation of AG ED 520; emphasis upon statistical techniques for students' individual problems.

524. Program Development in Agricultural Education (1-3) Analysis of occupational needs of students and employment prospects; organization of courses of study and other activities of teachers.

530. Agricultural College Teaching (3) Selection and organization of subject matter for specific courses, methods of learning, teaching devices, techniques of teaching, and measurement of results of teaching.

590. Colloquium (1-3)

596. Individual Studies (1-9)

597. Special Topics (1-9)

AGRICULTURAL ENGINEERING (AG E)

DENNIS E. BUFFINGTON, *Head of the Department*
250 Agricultural Building
814-865-7792

Degrees Conferred: Ph.D., M.S.

Senior Members of the Graduate Faculty
Dennis E. Buffington, Ph.D. (Minnesota), P.E. *Professor of Agricultural Engineering*
Albert R. Jarrett, Ph.D. (Penn State), P.E. *Professor of Agricultural Engineering*
Harvey B. Manbeck, Ph.D. (Oklahoma State), P.E. *Professor of Agricultural Engineering*
Charles T. Morrow, Ph.D. (Penn State), P.E. *Professor of Agricultural Engineering*
Sverker P. E. Persson, Ph.D. (Michigan State) *Professor of Agricultural Engineering*
Virendra M. Puri, Ph.D. (Delaware) *Assistant Professor of Agricultural Engineering*
Paul N. Walker, Ph.D. (Massachusetts), P.E. *Associate Professor of Agricultural Engineering*
Carlos A. Zuritz, Ph.D. (California) *Assistant Professor of Agricultural Engineering*

Associate Members of the Graduate Faculty
Paul M. Anderson, M.S. (Penn State) *Associate Professor of Agricultural Engineering*
Jon M. Carson, Ph.D. (Illinois) *Assistant Professor of Agricultural Engineering*
Donald R. Daum, M.S. (Penn State), P.E. *Professor of Agricultural Engineering*
Herschel A. Elliott, Ph.D. (Delaware) *Associate Professor of Agricultural Engineering*
Robert E. Graves, Ph.D. (Massachusetts), P.E. *Professor of Agricultural Engineering*
James W. Hilton, Ph.D. (Iowa State) *Associate Professor of Agricultural Engineering*
James R. Hoover, Ph.D. (South Dakota State), P.E. *Adjunct Associate Professor of Agricultural Engineering*
Daniel J. Meyer, Ph.D. (Wisconsin) *Associate Professor of Agricultural Engineering*
Dennis J. Murphy, Ph.D. (Penn State) *Associate Professor of Agricultural Engineering*
Mark D. Shaw, M.S. (Penn State), P.E. *Associate Professor of Agricultural Engineering*

Graduate programs are available in the areas of the physical properties of biomaterials, protected plant and animal production, food engineering including freezing and thermal processing, agricultural structures, agricultural byproduct utilization, agricultural systems engineering, biomass energy conservation, alternative energy sources, agronomic crop mechanization, forage and animal interaction, horticultural engineering, microclimate modification, soil dynamics, infiltration, drainage, irrigation, and natural resources management and conservation.

Excellent facilities, including equipment and instrumentation, are available for research in the designated areas. Among the special facilities are controlled environmental chambers; a waste and pollutants evaluation facility; plant growth structures for modified atmosphere; hydraulic power and engines laboratories; a general purpose analog computer; a microcomputer laboratory; data-processing systems, including interactive access to University computer facilities; and laboratories for research on physical properties of agricultural materials. Special equipment is available for physical properties work, including testing machines complete with environmental chambers and data acquisition systems, a polariscope for photoelastic stress analysis, triaxial testing equipment, and other unique and specially designed testing facilities. Equipment is also available for studying thermal properties of food materials. Special facilities outside the Agricultural Engineering Building include a mushroom research and demonstration facility and a 1,500-acre agricultural research center for cooperative work with agronomic and horticultural production systems.

Admission Requirements

All students must submit scores from the General Aptitude Test of the Graduate Record Examination (GRE) prior to admission except those students who have an ABET-accredited engineering degree. Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin*.

An undergraduate major in engineering is normally a prerequisite to work in the major.

Students without an undergraduate engineering degree will be considered for admission on a provisional basis pending the completion of a number of additional credits to be specified on an individual basis. These remedial courses must be completed with a minimum grade-point average of 2.75. The best-qualified applicants will be accepted up to the number of spaces that are available for new students.

Master's Degree Requirements

All candidates for the M.S. degree must prepare a thesis. In addition, 30 credits of course work are required. Each program should include at least one course from the areas of agricultural or biological science, mathematics, and statistics. All students are expected to attend announced departmental seminars. Students must register for all fall and spring semesters until graduation. Additional program details are contained in a syllabus available from the department.

Doctoral Degree Requirements

The communication and foreign language requirement for the Ph.D. degree may be satisfied by either 9 credits of courses in an approved sequence or a foreign language. Prior approval by the Ph.D. Advisory Committee must be obtained to study a foreign language other than French, German, Russian, or Spanish.

All students should complete a master's program before pursuing the doctoral degree.

A graduate student who wants to become a doctoral candidate must be approved for candidacy by the candidacy examination committee of the agricultural engineering department. No specified number of courses completed or credits earned are required by the department, except that the candidate who has completed the M.S. degree must take at least 9 credits of course work and 2 credits of colloquium in the agricultural engineering department. All students are expected to attend announced departmental seminars. A doctoral committee appointed by the Graduate School will approve the student's course work program. Typical programs of study may be found in a syllabus available from the department.

Other Relevant Information

Continuous registration is required for all graduate students until the thesis is approved.

Student Aid

Graduate assistantships available through the program and other forms of student aid are described in the STUDENT AID section of the *Graduate Bulletin*.

AGRICULTURAL ENGINEERING (AG E)

401. Farm Mechanics for Teachers of Vocational Agriculture (1½-9)
418. Microcomputers in Agriculture (2)
420. Seminar (1)
425. Physical Processes in Food Manufacturing (3)
428. Electric Power and Instrumentation in Agriculture (3)
429. Farm Machinery Management (3)

432. Principles of Agricultural Buildings (3)
434. Principles and Design of Farm Tractors and Machines (3)
435. Principles of Agricultural Processing (3)
437. Principles of Soil-Water Engineering (3)
438. Agricultural Measurements and Control Systems (3)
453. Mechanical Properties of Agricultural Materials (3)
457. Land Waste Disposal (3)
460. Power Sources for Agriculture (3)
461. Hydraulic Power in Agricultural Equipment (3)
462. Functional Design of Agricultural Structures (3)
464. Design of Agricultural Machines (3)
465. Food Process Engineering (3)
467. Soil and Water Management Systems Design (3)
469. Optimization of Agricultural Systems and Energy Utilization (3)
488. Introduction to Agricultural Engineering Design (1)
489. Agricultural Engineering Design Problem (1-3)
490. Agricultural Mechanization Seminar (1)
494. Senior Thesis (1-9)
495. Agricultural Engineering Internship (1-6)
496. Independent Studies (1-18)
497. Special Topics (1-9)

503. Physical Properties of Plant and Animal Products (3) Physical characteristics; mechanical, rheological, thermal, electrical, and optical properties in relation to handling, storage, processing, and quality evaluation.

505. Experimental and Applied Instrumentation (4) The theory and application of electronics for instrumentation and experimental research.

510. Theory of Soil-Machine Interaction (3) Performance of agricultural and earth-moving machines and off-road vehicles related to soil stress and strain in contact region. Prerequisite: AG E 434 or C E 244 or M E 050.

511. Theory and Design of Agricultural Machine Components (3) Functional analysis of machine components for cutting, compressing, threshing, sorting, metering, and transporting agricultural products and materials. Prerequisite: AG E 434 or M E 050.

512. Structural and Environmental Analysis of Agricultural Buildings (3) Advanced topics on the design and analysis of structural and environmental control systems for agricultural buildings. Prerequisites: AG E 432, 462.

513. Applied Finite Element, Finite Difference, and Boundary Element Methods (3) Applications of numerical methods in the areas of structures, fluid dynamics, heat and mass transfer, and machine design. Prerequisite: consent of program head.

515. Thermal Phenomena in Food Engineering (3) Heat and mass transfer phenomena, nutrient degradation rates, and energy use in food processing.

519. Control of Agricultural Processes Using Microcomputers (1-3) Design and application of control systems for agricultural processes and equipment using microcomputers. Prerequisite: AG E 418.

562. (E MCH 562) Boundary Element Analysis (3) Numerical solution of boundary value problems using fundamental solutions; application to problems in potential theory, diffusion, and elastostatics. Prerequisite: AG E 513 or E MCH 461 or E MCH 560.

590. Colloquium (1-3)

596. Individual Studies (1-9)

597. Special Topics (1-9)

602. Supervised Experience in College Teaching (1-3 per semester, maximum of 6)

AGRICULTURAL MECHANIZATION (AG M)

DENNIS E. BUFFINGTON, *Head of the Department of Agricultural Engineering*
250 Agricultural Engineering Building
814-865-7792

Degree Conferred: M.Agr.

Senior Members of the Graduate Faculty
Dennis E. Buffington, Ph.D. (Minnesota), P.E. *Professor of Agricultural Engineering*
Albert R. Jarrett, Ph.D. (Penn State), P.E. *Professor of Agricultural Engineering*
Harvey B. Manbeck, Ph.D. (Oklahoma State), P.E. *Professor of Agricultural Engineering*
Charles T. Morrow, Ph.D. (Penn State), P.E. *Professor of Agricultural Engineering*
Sverker P.E. Persson, Ph.D. (Michigan State) *Professor of Agricultural Engineering*
Virendra M. Puri, Ph.D. (Delaware) *Assistant Professor of Agricultural Engineering*
Paul N. Walker, Ph.D. (Massachusetts), P.E. *Associate Professor of Agricultural Engineering*
Carlos A. Zuritz, Ph.D. (California) *Assistant Professor of Agricultural Engineering*

Associate Members of the Graduate Faculty
Paul M. Anderson, M.S. (Penn State) *Associate Professor of Agricultural Engineering*
Jon M. Carson, Ph.D. (Illinois) *Assistant Professor of Agricultural Engineering*
Donald R. Daum, M.S. (Penn State), P.E. *Professor of Agricultural Engineering*
Herschel A. Elliott, Ph.D. (Delaware) *Associate Professor of Agricultural Engineering*
Robert E. Graves, Ph.D. (Massachusetts), P.E. *Professor of Agricultural Engineering*
James W. Hilton, Ph.D. (Iowa State) *Associate Professor of Agricultural Engineering*
James R. Hoover, Ph.D. (South Dakota State), P.E. *Adjunct Associate Professor of Agricultural Engineering*
Daniel J. Meyer, Ph.D. (Wisconsin) *Associate Professor of Agricultural Engineering*
Dennis J. Murphy, Ph.D. (Penn State) *Associate Professor of Agricultural Engineering*
Mark D. Shaw, M.S. (Penn State), P.E. *Associate Professor of Agricultural Engineering*

This program is designed to provide opportunities to help individuals aid the agricultural industry to cope more successfully with rapidly changing technology and the challenges to increase food production with greater efficiency in the use of energy and other production inputs. The Master of Agriculture is a professional degree providing opportunities for students to increase their knowledge and competencies in the various phases of agricultural mechanization. Specific graduate program emphases are available in fields such as soil and water management, crop production, animal science, and agricultural equipment. Special facilities available to students are described under the Agricultural Engineering graduate program listing in the *Graduate Bulletin*.

Admission Requirements
Scores from the Graduate Record Examination (GRE), or from a comparable substitute examination accepted by a graduate program and authorized by the dean of the Graduate School, are required for admission. A student may be admitted provisionally for graduate study in the program without these scores. Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin*.

Specific admission requirements include an undergraduate degree in agriculture or a related area and mathematics through MATH 110 or 140, or equivalent course work. Without this training, students will be admitted to this program only after completion of three courses or 9 credits in plant science, animal science, and soil science, plus two courses or 6 credits in agricultural engineering. The best-qualified applicants will be accepted up to the number of spaces available for new students.

Master's Degree Requirements
The following specific requirements are in addition to those specified for the M.Agr. degree: AG 400 or an equivalent course or background in statistics: CMPSC 201 or an equivalent course or background in computer science; 12 credits in AG E courses, including AG E 596 and the preparation of a paper or AG E 495 (3 credits); AG E 590 and the presentation of a paper; 6 credits in agricultural science or production courses; and additional courses for a total of 30 graduate credits.

Other Relevant Information
Continuous registration is required for all graduate students until all degree requirements are satisfied.

Student Aid
Graduate assistantships normally are not available to students enrolled in this program. Other forms of student aid are described in the STUDENT AID section of the *Graduate Bulletin*.

AGRONOMY (AGRO)

A. J. TURGEON, *Head of the Department*
119 Tyson Building
814-865-6541

Degrees Conferred: Ph.D., M.S., M.Agr.

Senior Members of the Graduate Faculty
Dale E. Baker, Ph.D. (Missouri) *Professor of Soil Chemistry*
Jean-Marc Bollag, Ph.D. (Basel) *Professor of Soil Microbiology*
Edward J. Ciolkosz, Ph.D. (Wisconsin) *Professor of Soil Genesis and Morphology*
Richard W. Cleveland, Ph.D. (California) *Professor of Plant Breeding*
Robert L. Cunningham, Ph.D. (Washington State) *Professor of Soil Genesis and Morphology*
Joseph M. Duich, Ph.D. (Penn State) *Professor of Turfgrass Science*
Steven L. Fales, Ph.D. (Purdue) *Associate Professor of Agronomy*
Richard H. Fox, Ph.D. (Arizona) *Professor of Soil Science*
Daniel D. Fritton, Ph.D. (Iowa State) *Professor of Soil Physics*
David L. Gustine, Ph.D. (Michigan State) *Adjunct Associate Professor of Crop Physiology*
Jon K. Hall, Ph.D. (Penn State) *Associate Professor of Soil Chemistry*
Joseph D. Harrington, Ph.D. (Penn State) *Professor of Agronomy*
Richard R. Hill, Jr., Ph.D. (Cornell) *Adjunct Professor of Plant Breeding*
Leon J. Johnson, Ph.D. (Penn State) *Professor of Soil Mineralogy*
Melvin W. Johnson, Ph.D. (Wisconsin) *Associate Professor of Plant Breeding*
Gerald A. Jung, Ph.D. (Wisconsin) *Adjunct Professor of Agronomy*
William A. Kendall, Ph.D. (Ohio State) *Adjunct Professor of Crop Physiology*
Daniel P. Knievel, Ph.D. (Wisconsin) *Associate Professor of Crop Physiology*
Harold G. Marshall, Ph.D. (Minnesota) *Adjunct Professor of Plant Breeding*
Gary W. Petersen, Ph.D. (Wisconsin) *Professor of Soil Genesis and Morphology*
Harry B. Pionke, Ph.D. (Wisconsin) *Adjunct Professor of Soil Science*
Marvin L. Risius, Ph.D. (Cornell) *Professor of Plant Breeding*
Andrew S. Rogowski, Ph.D. (Iowa State) *Adjunct Professor of Soil Physics*
John S. Shenk, Ph.D. (Michigan State) *Professor of Plant Breeding*
James L. Starling, Ph.D. (Penn State) *Professor of Agronomy*
William C. Templeton, Jr., Ph.D. (Purdue) *Adjunct Professor of Agronomy*
A. J. Turgeon, Ph.D. (Michigan State) *Professor of Agronomy*
Donald V. Waddington, Ph.D. (Massachusetts) *Professor of Soil Science*
Thomas L. Watschke, Ph.D. (Virginia Polytechnic) *Professor of Turfgrass Science*

Associate Members of the Graduate Faculty
Douglas B. Beegle, Ph.D. (Penn State) *Assistant Professor of Agronomy*
Clyde C. Berg, Ph.D. (Washington State) *Adjunct Associate Professor of Agronomy*
Sidney C. Bosworth, Ph.D. (Kentucky) *Assistant Professor of Agronomy*
Nathan L. Hartwig, Ph.D. (Wisconsin) *Professor of Weed Science*
O. Elwood Hatley, Ph.D. (Purdue) *Professor of Agronomy Extension*
Les E. Lanyon, Ph.D. (Ohio State) *Associate Professor of Soil Fertility*
Roger Pennock, Ph.D. (Michigan State) *Professor of Soil Genesis and Morphology*
Ronald R. Schnabel, Ph.D. (Washington State) *Adjunct Assistant Professor of Soil Science*
Raymond F. Shipp, Ph.D. (Penn State) *Associate Professor of Agronomy Extension*
William L. Stout, Ph.D. (Penn State) *Adjunct Assistant Professor of Soil Science*

Agronomy graduate programs emphasize research that increases the efficiency of production of agronomic crops, improves the quality of food, feed, and fiber available for humans and animals, assists in the use and development of land resources, develops an understanding of the basic soil-plant-animal-climate complex of which humans are a part, and improves the overall quality of the human environment. Within this framework, students may specialize in soil science, crop science, or soil and crop management, including turfgrass management. Areas of specialization in soil science include chemistry, fertility, genesis and morphology, microbiology, mineralogy, and physics. Crop science specialities include breeding and genetics, ecology and management, physiology, and weed science.

Research facilities include a 340-acre experimental farm with irrigation facilities, a 22-acre turfgrass research center, greenhouses, service areas, and a number of well-equipped experimental laboratories. The department enjoys close collaboration with three U.S.D.A. research units — the Northeast Pasture Research Laboratory, the Northeast Watershed Research Center, and a small grains research unit, which add substantial strength to the research and graduate education capabilities of the department.

Admission Requirements

Scores from the Graduate Record Examination (GRE), or from a comparable substitute examination, are required for admission. At the discretion of the graduate standards committee, a student may be admitted provisionally for graduate study in the program without these scores. Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin*.

Prerequisites for major work in agronomy vary with the area of specialization and the degree sought, but courses in chemistry, mathematics, physics, geology, basic and applied biological sciences, and English communication skills are required. Applicants for the M.S. degree should have a baccalaureate degree including 76 credits of basic and applied natural sciences. For the M.Agr. degree program, an applicant must present a baccalaureate degree in agricultural or forest science.

A minimum junior-senior grade-point average of 3.00 is required for admission to the Agronomy master's degree programs. In addition, a grade-point average of 3.00 is required in all courses in the biological and physical sciences regardless of when taken. Exceptions to these requirements may be made for students with special backgrounds, abilities, and interests.

Admission to the Ph.D. program requires an M.S. or equivalent degree, and 100 credits (including credits of the baccalaureate degree) of basic and applied natural sciences. Applicants for the Ph.D. program will be evaluated on the quality of work completed in all previous degree programs.

Students who lack some of the prerequisite courses may be admitted but are required to take these courses without degree credit. The best-qualified applicants will be accepted up to the number of spaces available for new students.

Master's Degree Requirements

In addition to the general requirements for the M.S. degree as defined by the Graduate School, the department requires 6 credits of 400- or 500-level formal courses in a minor or general studies area. Participation in at least one Agronomy seminar course each semester is required, and students must register for at least 1 credit of an Agronomy seminar. An advisory committee will be appointed for each student, and additional courses and requirements may be determined by this advisory committee.

A thesis based on field and/or laboratory research is required for the M.S. degree. Candidates for the M.Agr. degree may prepare a paper in lieu of a thesis which is based on library research.

Both M.S. and M.Agr. candidates must pass a final examination.

Doctoral Degree Requirements

Beyond the general requirements for the Ph.D. defined by the Graduate School, the department has a number of specific requirements regarding course level and distribution that are defined in the departmental publication "Graduate Degrees in Agronomy." While a minimum number of courses for the degree is not specified, the doctoral advisory committee has the responsibility of specifying courses and credits essential for the education and development of the candidate. Students are expected to be educated in depth in a specific subfield of agronomy and to have a perspective of the general field. Normally, 55 to 60 credits in formal course work beyond the B.S. degree are required. Doctoral candidates are required to participate regularly in a departmental seminar and to register for at least 2 credits of the seminar during the Ph.D. program.

The communication and foreign language requirement for the Ph.D. degree may be met either by demonstrating a knowledge of at least one foreign language or by completing at least 6 credits of course work in an area of English communications approved by the student's advisory committee.

In addition to the candidacy, comprehensive, and final oral examinations, the department requires a competency examination to be taken after a student passes the candidacy. The purpose of this examination is to determine the student's strengths and weaknesses in pertinent subject matter and to assist the committee in providing direction relative to required course work.

Other Relevant Information

Every student has a close professional relationship with his or her faculty adviser. While research that is done for the thesis will be on subjects that fall within the ongoing research program of the adviser,

students are encouraged to propose research projects that are of interest to them. For the most part, all costs relative to the research program will be covered by the department. The department encourages professional development of students through participation in meetings of relevant professional societies and organizations.

Student Aid

Graduate research and teaching assistantships available to students in this program and other forms of student aid are described in the STUDENT AID section of the *Graduate Bulletin*.

AGRONOMY (AGRO)

401. Soil Composition and Physical Properties (3) *Fritton*
402. Chemistry of Soils and Fertilizers (3) *Fox*
403. Properties and Management of Tropical Soils (2) *Cunningham and Fox*
410. Crop Science (3) *Knievel*
411. Breeding of Field Crops (3) *Cleveland*
415. Soil Morphology, Mapping, and Land Use (3) *Petersen*
416. Soil Genesis and Classification (3) *Ciolkosz*
419. Soil Properties (4) *Baker*
420. Agronomic Case Studies in Soil, Plant, and Water Management (3) *Lanyon*
422. Conservation of Soil and Water Resources (3) *Cunningham*
423. Forage Crop Management (3) *Fales*
425. Field Crop Management (3) *Hatley*
436. Advanced Turfgrass Management (3) *Waddington*
438. Principles of Weed Control and Herbicide Properties (5) *Hartwig*
490. Agronomy Colloquium (1)
495. Internship (1-5)
496. Independent Studies (1-18)
497. Special Topics (1-9)

501. Soil Fertility (3) Soil-plant relations emphasizing recent concepts of ion accumulation by plants as affected by soil conditions and plant physiology. Prerequisites: AGRO 402, BIOL 441. *Hall*

506. Soil Physical Chemistry (4) Colloidal chemistry of soils emphasizing ion adsorption, double-layer theory, diffusion, and water properties. Prerequisites: AGRO 419; BIOCH 425 or CHEM 451. *Baker*

507. Soil Physics (3-4) Soil physical properties emphasizing water, heat, gas, and ion movement in unsaturated soils. Laboratory included with 4 credits. Prerequisites: 6 credits each of calculus, physics, and soils. *Fritton*

509. Methods of Genetic Analysis (3) Methods of qualitative genetics. Tests of hypotheses, homogeneity, linkage detection, calculations of recombination values, monosomic analysis, and tetrasomic inheritance. Prerequisites: 6 credits of genetics or plant breeding. *Cleveland*

510. Cytogenetics in Plant Breeding (3) Chromosomal heredity of agricultural plants. Chromosome morphology; cytogenetic behavior of aneuploids, haploids, auto- and allopolyploids, and interspecific hybrids. Prerequisites: 6 credits of genetics, including 3 credits of cytogenetics or cytology. *Cleveland*

511. Biometrical Plant Breeding (3) Quantitative genetics of plant populations; applications to breeding methodology and selection. Prerequisites: AGRO 512; 3 credits in plant breeding. *Hill and Risius*

512. Field Plot Technique (4) Ramifications of analysis of variance techniques; combining and analyzing data from several experiments; selection of valid error terms. Prerequisite: AG 400 or STAT 200. *Risius*

515. Nutritive Value of Crop Plants (3) Biochemical, physiological, genetic, and morphological nature of crop plants related to animal response. Laboratory includes nutritive evaluation procedures. Prerequisites: 3 credits of crop production and 6 credits of biochemistry and/or nutrition. *Shenk*

517. Crop Ecology and Physiology (3) Ecological and physiological factors affecting the productivity of crop plants. Prerequisite: AGRO 410. *Knievel*

518. Responses of Crop Plants to Environmental Stress (3) Physiological and ecological aspects of the response of crop plants to environmental stresses in establishment, persistence, and reproduction. Prerequisite: AGRO 410. *Knievel*

519. Nature of Soil Minerals (3) Constituent minerals of soils: modern methods for identification; relations to soil formation and agricultural practices. Prerequisite: AGRO 401. *Johnson*

523. Components of Forage-Animal Systems (3) Definition and analysis of important soil, plant, and animal components in forage-animal production systems. Development of conceptual systems models. Prerequisite: AGRO 423. *Fales*

545. The Application of Statistics to Field Experiments (4) Use of advanced experimental designs in planning, analyzing, and interpreting experiments; includes lattice designs, factorials, confounding, simple and multiple covariance techniques. Prerequisite: AGRO 512. *Risius and Shenk*

590. Colloquium (1-3)

596. Individual Studies (1-9)

597. Special Topics (1-9)

602. Supervised Experience in College Teaching (1-3 per semester, maximum of 6)

AMERICAN STUDIES (AMSTD)

SIMON J. BRONNER, *Coordinator, Graduate Program in American Studies*
Penn State Harrisburg, The Capital College
Middletown, PA 17057
717-948-6039

Degree Conferred: M.A.

Senior Members of the Graduate Faculty
Robert J. Graham, Ph.D. (Pennsylvania) *Associate Professor of Humanities and American Studies*
Theodora R. Graham, Ph.D. (Pennsylvania) *Associate Professor of Humanities and English*
Irwin Richman, Ph.D. (Pennsylvania) *Professor of American Studies and History*
Nancy M. Tischler, Ph.D. (Arkansas) *Professor of English and Humanities*

Associate Members of the Graduate Faculty
Michael L. Barton, Ph.D. (Pennsylvania) *Associate Professor of Social Science and American Studies*
Simon J. Bronner, Ph.D. (Indiana) *Associate Professor of Folklore and American Studies*
Eton F. Churchill, M.F.A. (Tulane) *Assistant Professor of Humanities and Multi-Media Journalism*
William J. Mahar, Ph.D. (Syracuse) *Associate Professor of Humanities and Music*
John S. Patterson, Ph.D. (Brown) *Associate Professor of American Studies and History*

This program, which is offered at Penn State Harrisburg, The Capital College, emphasizes the interdisciplinary study of American society and culture. It provides the student with the opportunity to acquire knowledge in the fields of history, literature, media, material culture museology, folklore, art, architecture, music, and to study the interrelationships linking those fields with important questions and issues in American life.

Strong ties with local educational and cultural institutions, including the William Penn Memorial Museum, Pennsylvania Farm Museum of Landis Valley, and the Dauphin County Historical Society, provide excellent learning opportunities for interested students.

This degree can be earned by full- or part-time study. As a convenience for working students, all 500-level courses are offered in the evening, and every attempt is made to meet the student's individual needs.

Admission Requirements
Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin*.

There are no course work prerequisites for admission to the master's program; however, a student must have received a baccalaureate degree from an accredited institution, earned under residence and credit conditions substantially equivalent to those required by Penn State. The application, tran-

scripts, two letters of recommendation, and a letter outlining personal goals and reasons for applying for admission to the program should be sent to Penn State Harrisburg, The Capital College, Graduate Office, Middletown, PA 17057.

Degree Requirements

The student is required to take a minimum of 30 credits, including at least 18 credits in the 500 series. An original scholarly master's paper or a creative project or a specialized examination is required for graduation. One to 6 credits in AMSTD 580 can be earned during work on the master's project.

Student Aid

Graduate assistantships available to students in this program and other forms of student aid are described in the STUDENT AID section of the *Graduate Bulletin*.

AMERICAN STUDIES (AMSTD)

REQUIRED COURSES

500. Theory and Methods (3) Introduction to graduate work in American Studies through exploration of the approaches, materials, and interpretation of the field.

580. Projects in American Studies (1-6) Independent exploration within American Studies; evidenced by major paper, film, exhibition, or specialized examination.

APPROPRIATE COURSES may be taken from the following list and from 500-level courses in other fields with the concurrence of the student's adviser.

511. Pivotal Books (3-9) Exploration of a number of books which have been particularly influential in shaping thinking about American civilization.

530. Topics in American Folklore (3) A detailed exploration of aspects of folklore and folklife in America.

533. American Civilization in the Eighteenth Century (3-9) Detailed investigation of specific topics in eighteenth-century American civilization.

534. American Civilization in the Nineteenth Century (3-9) Representative interdisciplinary investigation of social, historical, economic, and aesthetic forces predominant in nineteenth-century America.

535. American Civilization in the Twentieth Century (3-9) Detailed investigation of specific periods or topics in twentieth-century American civilization.

570. Topics in American Art (1-6) Various themes within the American arts will be explored under this rubric.

575. Museum Internship (3) A supervised museum internship experience featuring a "hands-on" introduction into aspects of the curatorial profession. Prerequisite: permission of instructor.

590. Colloquium (1-3)

596. Individual Studies (1-9)

597. Special Topics (1-9)

ADDITIONAL COURSES may be taken from the following list and from 400-level courses in other fields with the concurrence of the student's adviser.*

400. Early America, 1620-1828 (3)
403. American Ideas (3)
422. Westward Movement (3)
431. The American Character (3)
442. American Folklore (3)

*Descriptions of these courses can be found in *Penn State Harrisburg, The Capital College Bulletin.*

451. Civil War and Reconstruction (3)
452. The American Renaissance (3)
453. Industrial America (3)
454. Parties and Politics in America (3)
455. Americans at Work (3)
456. Mass Culture: The Popular Arts in America (3)
457. Ethnic America (3)
458. Contemporary America, 1945-Present (3)
459. America's Coming of Age 1914-1939 (3)
460. American Art and Architecture (3)
462. Modern Art and Architecture (3)
463. American Music (3)
469. American Indian Ethnology (3)
470. Regionalism in America (3)
480. Museums and Culture (3)
491. Seminar in American Culture (3)
495. Internship (1-6)
496. Independent Studies (1-18)
497. Special Topics (1-9)

ANATOMY (ANAT)

ALPHONSE E. LEURE-DUPREE, *Acting Chair of the Department*
The Milton S. Hershey Medical Center
Hershey, PA 17033
717-531-8650

Degrees Conferred: Ph.D., M.S.

Senior Members of the Graduate Faculty
Alphonse E. Leure-duPree, Ph.D. (London) *Associate Professor of Anatomy*
Bryce L. Munger, M.D. (Washington) *Professor and Chair of Anatomy*
Robert B. Page, M.D. (Columbia) *Professor of Neurosurgery and Anatomy*
Ian S. Zagon, Ph.D. (Colorado) *Associate Professor of Anatomy*

Associate Members of the Graduate Faculty
Carey D. Balaban, Ph.D. (Chicago) *Assistant Professor of Anatomy and Surgery*
William P. Bartlett, Ph.D. (Albany) *Assistant Professor of Anatomy*
Pamela C. Colony, Ph.D. (Boston) *Assistant Professor of Anatomy and Medicine*
James R. Connor, Ph.D. (California, Berkeley) *Assistant Professor of Anatomy*

The graduate program emphasizes the general areas of gross anatomy, histology/cytology, neuroanatomy/neurophysiology, or appropriate combinations of these areas. Approaches offered include morphological (descriptive, comparative, developmental), functional (physiological, chemical), and experimental.

Admission Requirements
Scores from the Graduate Record Examination (GRE), or from a comparable substitute examination accepted by a graduate program and authorized by the dean of the Graduate School, are required for admission. At the discretion of a graduate program, a student may be admitted provisionally for graduate study in a program without these scores. Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin*.

A bachelor's degree reflecting a reasonable background in zoology, biology, mathematics, or chemistry is required. Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests. Applicants must provide complete transcripts and two letters of recommendation. A personal interview is desirable.

Doctoral Degree Requirements
The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of one foreign language.

Other Relevant Information
This program is offered only at The Milton S. Hershey Medical Center.

Student Aid
Graduate assistantships available to students in this program and other forms of student aid are described in the STUDENT AID section of the *Graduate Bulletin*.

ANATOMY (ANAT)

503. Gross Anatomy (6) Gross structure, organization, and function of the human body, with laboratories devoted to dissection of the human body.

505. Microanatomy and Embryology (4) Light and electron microscopic structure of cells, specialized tissues, organization, basic organogenesis, microscopic correlation.

511. (NEURO 511) Neurobiology II (3) Structure and physiology of central and peripheral nervous system, including specific sense organs.

512. Human Embryology and Teratology (2) Study of developing human embryo, including gamete production and fusion, implantation, organogenesis, and major abnormalities of organ systems.

515. (NEURO 515) Developmental Neurobiology (2) Development of the nervous system in all aspects.

530. Dissection (2-4) Intensive laboratory study of selected regions of the human body. Coverage and credit arranged by consultation.

542. Comparative Neurology (3) Topics in functional anatomy and neurophysiology. The comparative approach to the organization of the mammalian nervous system will be stressed. Prerequisite: ANAT 511 or NEURO 511.

543. Sensory Processes (3) Morphological, physiological, and psychophysical aspects of mammalian sensory systems; emphasizing somatic, sensory, visual, and auditory systems. Prerequisite: ANAT 511 or NEURO 511.

544. Development and Regeneration of the Nervous System (3) Current problems in both development and regeneration in the nervous system based on research problems encountered in the literature. Prerequisites: neurobiology, microscopic anatomy, and biological chemistry.

545. Comparative Auditory and Visual Anatomy (3) An introduction to the morphology and evolution of the vertebrate eye and ear; individualized laboratory work arranged by consultation.

546. (CMBIO 546) Concepts of Development (2) This course evaluates developmental processes at the cellular and molecular level, with an emphasis on the regulatory mechanisms involved.

550. (CMBIO 550) Quantitative Optics and Cytology (3) Study of the various types of light microscopy instruments and application of these tools to quantitative measurements in biological systems.

590. Colloquium (1-3)

596. Individual Studies (1-9)

597. Special Topics (1-9)

ANIMAL INDUSTRY — See ANIMAL SCIENCE

ANIMAL NUTRITION — See NUTRITION

ANIMAL SCIENCE (AN SC)

PAUL J. WANGSNESS, *Head of the Department of Dairy and Animal Science*
324 Henning Building
814-863-3665

Degrees Conferred: Ph.D., M.S., M.Agr.

Senior Members of the Graduate Faculty
Clifton A. Baile, Ph.D. (Missouri) *Adjunct Professor of Animal Nutrition*
Craig R. Baumrucker, Ph.D. (Purdue) *Associate Professor of Animal Nutrition – Physiology*
Terry D. Etherton, Ph.D. (Minnesota) *Professor of Animal Nutrition*
Robert J. Flipse, Ph.D. (Michigan State) *Professor of Dairy Science*
Daniel R. Hagen, Ph.D. (Illinois) *Associate Professor of Animal Science*
George L. Hargrove, Ph.D. (North Carolina State) *Professor of Dairy Science*
Truman V. Hershberger, Ph.D. (Ohio State) *Associate Professor of Animal Nutrition*
Gary J. Killian, Ph.D. (Penn State) *Associate Professor of Animal Science*
Lawrence D. Muller, Ph.D. (Purdue) *Professor of Dairy Science*
Tsuneo Y. Tanabe, Ph.D. (Wisconsin) *Associate Professor of Dairy Physiology*
Paul J. Wangsness, Ph.D. (Iowa State) *Professor of Animal Nutrition*
Lowell L. Wilson, Ph.D. (South Dakota State) *Professor of Animal Science*

Associate Members of the Graduate Faculty
Stephen M. Abrams, Ph.D. (Florida) *Adjunct Assistant Professor of Dairy Science*
Richard S. Adams, Ph.D. (Minnesota) *Professor of Dairy Science*
Erskine H. Cash, Ph.D. (Michigan State) *Professor of Animal Science*
Daniel R. Deaver, Ph.D. (West Virginia) *Assistant Professor of Animal Science*
Clair C. Engle, Ph.D. (Georgia) *Associate Professor of Animal Science*
Harold W. Harpster, Ph.D. (Michigan State) *Associate Professor of Animal Nutrition*
C. William Heald, Ph.D. (Virginia Polytechnic) *Professor of Dairy Science*
Arlyn J. Heinrichs, Ph.D. (Ohio State) *Assistant Professor of Dairy and Animal Science Extension*
Joseph G. Hlubik, Ph.D. (Michigan State) *Assistant Professor of Dairy Science*
Ronald S. Kensinger, Ph.D. (Florida) *Associate Professor of Animal Nutrition – Physiology*
Kenneth B. Kephart, Ph.D. (Penn State) *Assistant Professor of Animal Science*
Thomas L. Merritt, Ph.D. (Ohio State) *Professor of Animal Science*
Michael L. O'Connor, Ph.D. (Virginia Polytechnic) *Associate Professor of Dairy Science*
Paul R. Shellenberger, Ph.D. (Iowa State) *Professor of Dairy Science*
Lawrence W. Specht, Ph.D. (Michigan State) *Professor of Dairy Science*
Gabriella A. Varga, Ph.D. (Maryland) *Assistant Professor of Animal Science*

Students may specialize in animal management systems; breeding and genetics; meat science; metabolism, including growth and body composition; nutrition of various farm animal species; and reproductive, lactational, and general animal physiology. Ruminant, nonruminant, small-animal, and wildlife species are available.

Admission Requirements
Scores from the Graduate Record Examination (GRE) are required for admission. A student may be admitted provisionally without these scores. Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin.*

Prerequisite to graduate work is the completion of an undergraduate major in animal science, dairy science, or a related area. The undergraduate program must include biological sciences, chemistry, mathematics, and (except for M.Agr.) general physics. Students may be admitted with limited deficiency but are required to make up undergraduate deficiency work without degree credit.

Students with a 2.80 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.80 grade-point average may be made for students with special backgrounds, abilities, and interests.

Degree Requirements
The M.Agr. is a professional program designed to prepare individuals for specialist and management positions in county agricultural extension, government, or industry and does not require a thesis. The academic M.S. and Ph.D. programs require a thesis and are designed for those primarily interested in education and research. The requirements of these programs are detailed in the departmental publica-

tion "Requirements of the Graduate Program in Animal Science." The communication and foreign language requirement for the Ph.D. degree may be satisfied by competence in either one foreign language or communication skills.

Student Aid

In addition to the fellowships, traineeships, graduate assistantships, and other forms of financial aid described in the STUDENT AID section of the *Graduate Bulletin,* the following award typically has been available to graduate students in this program:

MICASU SCHOLARSHIP — Available to a graduate student in animal science who has financial need and who has demonstrated academic achievement and improvement during the graduate program; stipend variable.

ANIMAL SCIENCE (AN SC)

406. SWINE MANAGEMENT AND PRODUCTION (3)
407. ADVANCED HORSE PRODUCTION AND MANAGEMENT (2)
408. SHEEP PRODUCTION AND MANAGEMENT (3)
409. BEEF PRODUCTION AND MANAGEMENT (3)
410. DAIRY HERD MANAGEMENT (4)
420. ANIMAL NUTRITION AND FEEDING TECHNOLOGY (2)
421. APPLIED FEEDING OF BEEF CATTLE AND SHEEP (2)
422. APPLIED FEEDING OF DAIRY CATTLE (2)
423. APPLIED FEEDING OF SWINE, POULTRY, AND LABORATORY ANIMALS (1)
427. MILK SECRETION (3)
431. PHYSIOLOGY OF REPRODUCTION IN FARM ANIMALS (3)
442. QUANTITATIVE INHERITANCE AND ANIMAL BREEDING (3)
490. ANIMAL PRODUCTION COLLOQUIUM (1)
491. DAIRY PRODUCTION COLLOQUIUM (1)
496. INDEPENDENT STUDIES (1-18)
497. SPECIAL TOPICS (1-9)

506. ANIMAL BREEDING (1-6) Special problems in animal genetics as applied to breeding and improvement of horses, cattle, sheep, and swine. Prerequisites: AN SC 322; 3 credits in statistics.

510. ANIMAL SCIENCE RESEARCH METHODS (3) Application of scientific method; experimental design and procedures; analyzing, interpreting, and reporting research results. Prerequisite: 3 credits of 400-level statistics.

511. ANIMAL NUTRITION AND MANAGEMENT (1-6) Developments in the nutrition and management of farm livestock. Prerequisites: AN SC 406 or 407 or 408 or 409 or 410; A NTR 401; FD SC 401.

512. STUDIES IN MILK SECRETION (1-6) Physiology of milk secretion. Prerequisite: AN SC 427.

514. ANIMAL GROWTH AND DEVELOPMENT (3) Cellular, metabolic, and nutritional aspects of fetal and postnatal tissue growth; role of the endocrine system in regulation of animal growth. Prerequisites: 3 credits in biochemistry; 3 credits in physiology.

515. ADVANCED PHYSIOLOGY OF REPRODUCTION IN FARM ANIMALS (1-6) Advanced physiology of reproduction in farm animals. Prerequisites: 3 credits each in reproductive physiology, systemic physiology, and endocrinology.

590. COLLOQUIUM (1-3)

596. INDIVIDUAL STUDIES (1-9)

597. SPECIAL TOPICS (1-9)

602. SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-3 per semester, maximum of 6)

NOTE: *See NUTRITION, PHYSIOLOGY, and FOOD SCIENCE.*

ANTHROPOLOGY (ANTH)

KENNETH M. WEISS, *Head of the Department*
409 Carpenter Building
814-865-2509

Degrees Conferred: Ph.D., M.A.

Senior Members of the Graduate Faculty
Paul T. Baker, Ph.D. (Harvard) *Evan Pugh Professor Emeritus of Anthropology*
Stephen J. Beckerman, Ph.D. (New Mexico) *Assistant Professor of Anthropology*
Robert B. Eckhardt, Ph.D. (Michigan) *Associate Professor of Anthropology*
Henry C. Harpending, Ph.D. (Harvard) *Professor of Anthropology and Human Development*
James W. Hatch, Ph.D. (Penn State) *Associate Professor of Anthropology*
Edward E. Hunt, Jr., Ph.D. (Harvard) *Professor Emeritus of Anthropology and Health Education*
Jeffrey A. Kurland, Ph.D. (Harvard) *Associate Professor of Anthropology and Human Development*
Frederick R. Matson, Ph.D. (Michigan) *Professor Emeritus of Archaeology*
Joseph W. Michels, Ph.D. (UCLA) *Professor of Anthropology*
Warren T. Morrill, Ph.D. (Chicago) *Professor of Anthropology*
William T. Sanders, Ph.D. (Harvard) *Evan Pugh Professor of Anthropology*
David L. Webster, Ph.D. (Minnesota) *Associate Professor of Anthropology*
Kenneth M. Weiss, Ph.D. (Michigan) *Professor of Anthropology*
Ellen M. Woolford, Ph.D. (Duke) *Assistant Professor of Anthropology and Linguistics*

Associate Members of the Graduate Faculty
William S. Abruzzi, Ph.D. (SUNY-Binghamton) *Assistant Professor of Anthropology (Ogontz)*
George R. Milner, Ph.D. (Northwestern) *Assistant Professor of Anthropology*
Gary S. Webster, Ph.D. (Penn State) *Assistant Professor of Anthropology (Mont Alto)*

The master's program is designed to train students in general anthropology. The doctoral program is structured to train students in the following areas of specialization: ethnology (with subspecialization in social anthropology, demographic anthropology, cognitive anthropology, or cultural evolution and ecology); archaeology (with subspecialization in cultural ecology, analytical approaches, technological methods, or culture areas); biological anthropology (with subspecialization in human adaptability, genetics, biological demography, human evolution, or the behavioral biology of human and nonhuman primates).

Admission Requirements

Scores from the Graduate Record Examination (GRE), or from a comparable substitute examination accepted by a graduate program and authorized by the dean of the Graduate School, are required for admission. At the discretion of a graduate program, a student may be admitted provisionally for graduate study in a program without these scores. Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin.*

Undergraduate preparation must include 12 credits in anthropology and archaeology or their equivalent. A student with an excellent record but who does not meet these requirements may be admitted provided course deficiencies are made up without graduate credit. Students with a 3.00 or higher junior-senior average and with appropriate course backgrounds who have research interests directly related to the special anthropological competencies within the department will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

Master's Degree Requirements

M.A. candidates may submit either a thesis or a term paper. If the latter is chosen, 6 credits in 500-level courses in the major field must be scheduled in lieu of thesis credits. The M.A. degree may be bypassed by exceptional candidates for the Ph.D. degree.

Doctoral Degree Requirements

The communication and foreign language requirement for the Ph.D. degree includes a reading knowledge of a foreign language plus an option from among additional foreign languages, field languages, linguistics, or statistics.

Student Aid

In addition to the fellowships, traineeships, graduate assistantships, and other forms of financial aid described in the STUDENT AID section of the *Graduate Bulletin,* the following awards typically have been available to graduate students in this program:

Hill Fellowships for Study in Anthropology — Details available from Professor Kenneth M. Weiss, head of the Department of Anthropology, 409 Carpenter Building.

ANTHROPOLOGY (ANTH)

401. Human Evolution: The Material Evidence (3)
402. Human Adaptation (3)
405. Primatology (3)
408. Anthropological Demography (3)
409. Quantitative Analysis of Anthropological Data (2)
410. Osteology Laboratory (1)
411. Descriptive Methods Laboratory (1)
412. Anthropological Genetics Laboratory (1)
415. (EDTHP 415) Anthropology of Education (3)
420. Archaeology of the Near East (3)
422. Meso-American Archaeology and Ethnography (4)
423. The Evolution of American Indian Culture (4)
440. South American Tribal Societies (3)
441. Ethnology of the Andean Region (3)
450. Comparative Social Organization (3)
451. Economic Anthropology (3)
453. (SOC 453) Religion of Traditional Peoples (3)
454. Political Anthropology (3)
456. Cultural Ecology (3)
457. Language in Culture (3)
458. Primate Sociobiology (3)
464. (BIOL 464) Sociobiology (3)
471. Human Evolutionary Biology I (3)
472. Human Evolutionary Biology II (3)
473. Genes, Peoples, and Diseases (3)
474. Ecology of Gender (3)
488. Archaeological Methods and Theory (3)
492. Intermediate Field Methods (3-6)
493. Field Techniques (3-6)
495. Internship in Medical Anthropology (6-9)
496. Independent Studies (1-18)
497. Special Topics (1-9)

501. Human Evolution: The Material Evidence (4) Human origins as seen in the fossil record and comparative biology of humans and their primate relatives.

502. Human Adaptation Theory (4) Theory, mechanism, and examples of how human populations biologically adapted to varying environments. Prerequisite: 3 credits in physical anthropology.

508. Research Problems in Cultural History (3-9)

511. (HL ED 511) Health Implications in the Growth and Development of School Children (3) Child growth and development emphasis for teachers; medical inspection and examination; preschool program; early habit formations; behavior problems.

513. (HL ED 513) Health Implications in Maturity and Aging (3) Changes in the human body in maturity and aging; mechanisms of physiologic aging; implications for health and preventive medicine. Prerequisite: ANTH (HL ED) 511.

522-523. Ecological Theory in Anthropology (3 each) Human biology, culture history, and culture variation from the ecological perspective. Two-semester enrollment required. Prerequisites: 6 credits in anthropology.

530. Individual Readings in Anthropology (1-6) Reading or research in selected aspects of general anthropology.

531. Individual Research in Anthropology (3-12)

545. Seminar in Anthropology (1-9) Critical analysis of research in selected areas of anthropology.

557. Behavioral Anthropology I: Cognition (3) Cognitive anthropology, emphasizing kinship systems, cultural categories, and anthropological linguistics.

558. Behavioral Anthropology II: Evolution (3) Biological bases of social behavior, emphasizing sociobiological and behavioral ecological models of social adaptation.

559. Behavioral Anthropology III: Ecology (3) Ecological anthropology, emphasizing the adaptive aspects of subsistence, including foraging and settlement pattern.

560. History of Anthropological Theory (3) Survey of origin and development of anthropology in the nineteenth century and trends during the twentieth century. Prerequisite: ANTH 450.

561. Field Methods in Anthropology (3-9) Individual field work in any aspect of anthropology, supervised by staff of professional rank.

562. Laboratory Methods in Anthropology (3-9) Supervised laboratory research, utilizing materials from physical anthropology or archaeology or cultural anthropology.

563. Seminar in Linguistic Anthropology (3-6) Organized research on special topics in linguistic anthropology.

564. Topics in Sociobiology and Behavioral Ecology (3-6) Critical analysis of specialized topics in sociobiology and behavioral ecology. Prerequisite: an introductory course in anthropology or biology.

571. Principles of Human Population Biology I (3) Mechanisms and quantification of human genetic variation and survey of evolutionary aspects of human ecology, life cycle, and population biology.

572. Principles of Human Population Biology II (3) How human genetic variation is detected, the assessment of human quantitative genetic traits, and application to the human fossil record.

573. Anthropological Genetics of Disease (3) Epidemiological and genetic approaches to understanding patterns of difference in disease susceptibility and their evolution in human populations. Prerequisites: 6 credits in biology or genetics, 6 credits in statistics, biostatistics, or epidemiology.

588. Method and Theory in Archaeology (4) Methodological strategies and tactics in archaeological research; major theories in cultural anthropology as applied to archaeological data.

590. Colloquium (1-3) Continuing seminars which consist of a series of individual lectures by faculty, students, or outside speakers.

593. (BIOL 593, ENT 593, GEOSC 593, INTAG 593) Tropical Field Studies (Organization for Tropical Studies) (8) An intensive field course concentrating on field problems, experimental design, and data analysis in tropical habitats. Prerequisite: approval by the Committee on Tropical Studies.

596. Individual Studies (1-9) Creative projects, including nonthesis research, which are supervised on an individual basis and which fall outside the scope of formal courses. Prerequisite: prior approval of proposed assignment by instructor.

597. Special Topics (1-9)

ARCHITECTURAL ENGINEERING (A E)

LOUIS F. GESCHWINDNER, *In Charge of the Graduate Program*
104 Engineering A Building
814-865-6394

Degree Conferred: M.S.

Senior Members of the Graduate Faculty
Louis F. Geschwindner, Ph.D. (Penn State) *Associate Professor of Architectural Engineering*
Stanley A. Mumma, Ph.D. (Illinois) *Professor of Architectural Engineering*
Paul A. Seaburg, Ph.D. (Wisconsin) *Professor of Architectural Engineering*
Luis H. Summers, Ph.D. (Notre Dame) *Professor of Architectural Engineering*
Jiri Tichy, D.Sc. (Prague Inst. of Tech.) *Professor of Architectural Engineering*

Associate Members of the Graduate Faculty
Gifford H. Albright, S.M. (MIT) *Professor of Architectural Engineering*
Howard F. Kingsbury, M.S. (Penn State) *Associate Professor of Architectural Engineering*
Charles A. Merica, M.Sc.E. (Stanford) *Associate Professor of Architectural Engineering*
Victor E. Sanvido, Ph.D. (Stanford) *Assistant Professor of Architectural Engineering*

Students may specialize in structural analysis and design, heating, ventilating and air-conditioning engineering (including energy conservation and energy management in building and solar energy), illumination, acoustics, materials of construction, and building construction management. Computer applications to any of the above areas may be pursued.

Admission Requirements
Scores from the Graduate Record Examination (GRE) are required for admission. Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin*.

For admission a student must have a strong background in some field of engineering; in engineering science or mechanics; or in architecture or other related areas if there is adequate preparation in the physical sciences and mathematics. The detailed requirements depend upon the student's area of special interest.

Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

Degree Requirements
Continuous registration is required for all graduate students until the thesis is approved.

Student Aid
Graduate assistantships available to students in this program and other forms of student aid are described in the STUDENT AID section of the *Graduate Bulletin*.

ARCHITECTURAL ENGINEERING (A E)

401. Structural Design of Buildings (3)
402. Structural Design of Buildings (3)
403. Structural Design of Buildings (3)
430. Indeterminate Structures (3)
431. Structural Design of Buildings (3)
439. Modern Structural Systems (3)
441. Integration of Architectural Engineering Systems (3)
454. Advanced Heating, Ventilating, and Air Conditioning (3)
455. Advanced Heating, Ventilating, and Air Conditioning System Design (3)
456. Solar Energy Building System Design (3)
457. Solar Passive Design and Energy Conservation (3)
458. Advanced Architectural Acoustics and Noise Control (3)
461. Basic Theory of Building Illumination (3)
464. Advanced Architectural Illumination Systems Design (3)
471. Building Construction Assemblies (3)
472. Building Construction Management (3)
473. Building Construction Management (3)
474. Building Construction Estimating (3)
475. Building Construction Engineering I (3)
476. Building Construction Engineering II (3)
477. Senior Building Construction Project (3)
481. Comprehensive Architectural Engineering Senior Project (4)
482. Comprehensive Architectural Engineering Senior Project (4)
486. Professional Engineering Practice (3)
494. Senior Thesis (1-9) Students must have approval of a thesis adviser before scheduling this course.
496. Independent Studies (1-18)
497. Special Topics (1-9)

545. Architectural Engineering Seminar (1-6) Current literature and special problems in architectural engineering; presentation of technical papers.

590. Colloquium (1-3)

594. Research Topics (1-18)

596. Individual Studies (1-9)

597. Special Topics (1-9)

ARCHITECTURE (ARCH)

ARTHUR ANDERSON, JR., *Acting Head of the Department*
206 Engineering Unit C
814-865-9535

Degrees Conferred: M.S.

Senior Members of the Graduate Faculty
Gideon Golany, Ph.D. (Hebrew-Jerusalem) *Professor of Urban and Regional Planning*
Wladyslaw A. Strumillo, Dr.Arch. (Polytechnic Institute, Warsaw) *Associate Professor of Architecture*

Associate Members of the Graduate Faculty
Arthur Anderson, Jr., M.F.A. (Princeton) *Associate Professor of Architecture*
Pier Luigi Bandini, Dr.Arch. (University of Florence, Italy) *Assistant Professor of Architecture*
Sidney Cohn, Ph.D. (North Carolina) *Professor of Architecture*
Louis Inserra, M.Arch. (Yale) *Associate Professor of Architecture*
Donald Kunze, Ph.D. (Penn State) *Assistant Professor of Architecture*
Howard Lawrence, M.Art (California) *Assistant Professor of Architecture*
Don A. Leon, M.Arch. (Penn State) *Associate Professor of Architecture*
Dennis Playdon, M.Arch. (Harvard) *Associate Professor of Architecture*

The Master of Science is an academic degree available to students with a professional degree in architecture reentering the University for study. Advanced studies are offered in architecture, urban design, planning, and computer applications in design and planning, and in other areas related to architecture. The student is offered an opportunity for independent research and extensive interdisciplinary work under the guidance of specialists and scholars in technical, cultural, industrial, and social fields.

Admission Requirements
Scores from the Graduate Record Examination (GRE), or from a comparable substitute examination accepted by a graduate program and authorized by the dean of the Graduate School, are required for admission. At the discretion of a graduate program, a student may be admitted provisionally for graduate study in a program without these scores. Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin*.

Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission.

All applicants must submit (1) a minimum of two statements of recommendation from faculty members acquainted with the applicant's academic history and/or recommendations by an undergraduate review committee; (2) a paper of no more than 500 words stating the applicant's concept of graduate education in architecture and describing his or her personal commitment and professional interests and goals; and (3) a portfolio of design work (architecture and planning projects) executed at the undergraduate level or under professional guidance, or independently, provided that such work can be evidenced as executed by the applicant. A minimum portfolio representation of one project for each year of academic undergraduate study, or its equivalent, is required.

The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

Degree Requirements
A total of 30 credits and a thesis, final project, or research paper are required for the Master of Science degree. This work includes required studio core courses at the 500 level (6 credits), a concentration area (12 credits), electives (6 credits), and the thesis or final project (6 credits).

Student Aid

Graduate assistantships available to students in this program and other forms of student aid are described in the STUDENT AID section of the *Graduate Bulletin*.

ARCHITECTURE (ARCH)

411. Planning and Design with Climate (3)
430. Design-Research II (6-12)
441. Architectural Design Analysis (4)
442. Architectural Design Analysis (4)
443. Architectural Design Analysis Inspection Trip (1)
451. Architectural Professional Practice (3)
461. Architectural Structural Systems I (3)
462. Architectural Structural Systems II (3)
463. Architectural Structural Systems III (3)
471. Environmental Control Systems I (3)
472. Environmental Control Systems II (3)
481. Advanced Architectural Data Systems I (3)
482. Advanced Architectural Data Systems II (3)
496. Independent Studies (1-18)
497. Special Topics (1-9)

510. Urban Design Policy and Implementation (3) Analysis of urban design: origins, function, accomplishments; examination of urban design policy of and problems encountered in various cities.

515. New Towns Planning Seminar (3) Examination of the process, concepts, and structure of new towns planning as a response to contemporary urban-regional development problems.

516. New Communities Seminar (3) Examination and evaluation of the new communities movement in the United States.

517. New Towns Planning Process (3) A systematic study and analysis of the sequence of actions in the new towns planning process.

518. New Towns Research Seminar (3) Advanced research seminar using comparative case studies of comprehensive contemporary issues of new towns planning. Prerequisites: ARCH 515, 517.

530. Architecture I (6-12) Problems in architectural planning and design. Programming and/or implementation methodologies and applications for various environmental design scales. Prerequisite: ARCH 430 or graduate standing.

531. Architecture II (6-12) Continuation of ARCH 530 with concentration and specialization options. Prerequisite: ARCH 530.

532. Comprehensive Planning Process Studio (6-12) Field case studies in analysis forecasting and projections of urban physical design elements. Preparation of comprehensive plan, regulations, and implementation.

535. New Towns Planning Studio (6-12) A team workshop of planning and design of new towns, involving data gathering, surveys, analysis, projection, and implementation.

570. Architecture Design, Structural and Environmental Systems Integration (3) Structural and environmental systems consultation with appropriate faculty to review and determine proper technical responses for the undergraduate fifth-year project. Prerequisites: ARCH 463, 471. Concurrent: ARCH 530.

591. Architectural Research (2-12) Guided research project.

596. Individual Studies (1-9)

597. Special Topics (1-9)

ART (ART)

JAMES STEPHENSON, *In charge of Graduate Programs in Art*
102 Visual Arts Building
814-865-0444

Degrees Conferred: M.A., M.F.A.

Senior Members of the Graduate Faculty
John A. Cook, M.F.A. (Iowa) *Professor of Art*
David R. DonTigny, M.A. (Montana) *Professor of Art*
Bruce R. Shobaken, M.F.A. (Minnesota) *Professor of Art*

Associate Members of the Graduate Faculty
Phillip Chan, M.A., M.F.A. (California) *Assistant Professor of Art*
Robin L. Gibson, M.F.A. (Wisconsin) *Assistant Professor of Art*
Kenneth R. Graves, M.F.A. (San Francisco Art Institute) *Associate Professor of Art*
William P. Hanson, Art Dipl. (Fine Arts, Boston) *Associate Professor of Art*
Marc Hessel, M.F.A. (Iowa) *Associate Professor of Art*
James Hopfensperger, M.A. (Illinois), M.F.A. (Michigan) *Assistant Professor of Art*
William Kinser, B.F.A. (California Institute) *Assistant Professor of Art*
Gerald Lang, M.F.A. (Minnesota) *Associate Professor of Art*
Jerrold Maddox, M.F.A. (Indiana) *Professor of Art*
Beryl Matthews, M.F.A. (Ohio State) *Assistant Professor of Art*
Richard Mayhew *Professor of Art*
William J. McHale, D.Ed. (Penn State) *Associate Professor of Art*
Robert Neffson, M.F.A. (Boston) *Assistant Professor of Art*
Diane Pepe, M.A. (New Mexico) *Associate Professor of Art*
Stephen Porter, M.F.A. (Cornell) *Associate Professor of Art*
Lanny B. Sommese, M.F.A. (Illinois) *Professor of Art*
James E. Stephenson, Jr., M.A. (Montana) *Professor of Art*

The M.A. program is planned to provide a broad range of experience and study in the visual arts. The M.F.A. program is planned to provide professional emphasis in a specific area of art.

Admission Requirements
Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin*.

Requirements for admission to the M.A. program include a broad undergraduate training in art and the presentation of a portfolio of the applicant's work.

Requirements for admission to the M.F.A. program include 36 credits in studio art with some indication of concentration in a chosen area and a statement of purpose concerning the professional aims of the candidate. A portfolio must be presented. A portfolio of slides (quality photographs for sculpture applicants), rather than actual work, is requested. A selection of no fewer than twenty examples should be presented. The majority of these should be in the area of the applicant's interest, but the portfolio should also include a lesser emphasis in related areas.

All students accepted for graduate study in art who lack the adequate undergraduate courses or show deficiencies in some area will be required to take additional course work without degree credit.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

Degree Requirements
A thesis in an area of specialization is required for the M.A. degree. A creative project and supporting monograph are required for the M.F.A. degree.

Student Aid
Graduate assistantships available to students in this program and other forms of student aid are described in the STUDENT AID section of the *Graduate Bulletin*.

ART (ART)

411. Seminar in Contemporary Art (3 per semester, maximum of 6)
415. Advanced Fiber Arts (4 per semester, maximum of 12)
417. Advanced Metal Arts (4 per semester, maximum of 12)
421. Drawing (4 per semester, maximum of 12)
430. Advanced Sculpture (4 per semester, maximum of 12)
445. Handmade Papermaking (4 per semester, maximum of 12)
448. Advanced Printmaking (4 per semester, maximum of 12)
450. Advanced Painting (4 per semester, maximum of 12)
455. Advanced Painting Critique (4 per semester, maximum of 8)
460. Advanced Water-Based Media (4 per semester, maximum of 8)
470. Time and Sequence (4)
471-472. Senior Problems (4 each)
473. Graphic Design Seminar (3)
474. Graphic Design and the Computer (4)
480. Advanced Ceramic Arts (4 per semester, maximum of 12)
491. Photography and Other Disciplines (4 per semester, maximum of 12)
492. Creative Projects in Photography (4 per semester, maximum of 12)
494. Group Projects in Photography (4 per semester, maximum of 8)
496. Independent Studies (1-18)
497. Special Topics (1-9)

501. Art Research (2-6) Original study and practice in art relating to material, concept, or technique.

530. Advanced Sculpture (3-12) Individual projects in sculpture leading to the development of a collection or body of work representative of the artist.

545. Printmaking (2-12) Problems in printmaking leading to the development of a collection or body of work representative of the individual artist.

550. Painting (2-12) Individual problems in painting leading to the development of a collection or body of work representative of the artist.

570. Design (2-12) Individual projects in design, with special emphasis on professional practice in specialized fields of graphic design.

580. Ceramics (2-12) Experimental problems in ceramics leading to the development of a collection or body of work representative of the individual.

592. Photography (2-12) Individual projects in photography leading to the development of a body of specialized work representative of the artist. Prerequisites: 12 credits in ART 492.

596. Individual Studies (1-9)

ART EDUCATION (A ED)

BRENT G. WILSON, *In Charge of Graduate Programs in Art Education*
270 Chambers Building
814-865-6570

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Senior Members of the Graduate Faculty
Albert A. Anderson, Ph.D. (Ohio State) *Associate Professor of Art Education*
Kenneth R. Beittel, D.Ed. (Penn State) *Professor Emeritus of Art Education*
William Bradley, Ph.D. (Minnesota) *Associate Professor of Art Education*
Harlan E. Hoffa, D.Ed. (Penn State) *Professor of Art Education*
Robert W. Ott, D.Ed. (Penn State) *Professor of Art Education*
Alice M. Schwartz, D.Ed. (Penn State) *Professor Emerita of Art Education*
David B. Van Dommelen, M.A. (Michigan State) *Professor of Art Education*
Brent G. Wilson, Ph.D. (Ohio State) *Professor of Art Education*

Associate Member of the Graduate Faculty
Patricia Amburgy, Ph.D. (Illinois) *Assistant Professor of Art Education*

This program prepares students for careers in public school art teaching, art supervision, college teaching, administration, or research.

Admission Requirements
Scores from the Graduate Record Examination (GRE) or from the Miller Analogies Test (MAT) are required for admission. At the discretion of a graduate program, a student may be admitted provisionally for graduate study in a program without these scores. Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin*.

Students who seek admission to the graduate program must make formal application to the admissions committee of the art education program. To be admitted without deficiencies, the student is expected to have completed either a baccalaureate program in art education or a program leading to certification or a program considered by the admissions committee to be appropriate background for the applicant's degree objective. Such a program would include work in studio art, art history, art education, education, educational psychology, and psychology. Deficiencies may be made up by course work that is not counted as credit toward an advanced degree.

Students with a 2.75 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.75 grade-point average may be made for students with special backgrounds, abilities, and interests. Transcripts should indicate high attainment in appropriate academic and creative work, and recommendations should attest to scholarship and ability to work independently. Creative work, as shown by slides and photographs, should show a high level of involvement and sensitivity to aesthetic-forming processes.

Doctoral Degree Requirements
All students are expected to complete two years of teaching before receiving the doctoral degree. Such teaching may include supervised college teaching. A foreign language is not required of all Ph.D. degree candidates. Instead, students will include a series of research and communications studies pertinent to their interests and to their graduate programs and may include a foreign language approved by the doctoral committee.

Student Aid
Graduate assistantships available to students in this program and other forms of student aid are described in the STUDENT AID section of the *Graduate Bulletin*.

ART EDUCATION (A ED)

414. Advanced Crafts for Teachers (3-6)
420. Ceramics for Teachers (3)
434. Art Appreciation in the Educational Program (3)
435. Art in the Elementary School (3)
436. Art in the Secondary School (3)
440. Arts Institutions (3)
486. Current Problems in Art Education (2-3)
488. Advanced Mural Painting in Schools (3)
489. Art Experiences with Children (3)
490. Introduction to Research in Art Education (3)
494. Schools and Museums (3)
495. Internship in Art Experiences (12)
496. Independent Studies (1-18)
497. Special Topics (1-9)

501. Seminar in Art Education (1-6) The analysis of fundamental concepts derived from related disciplines; the examination of current problems; current literature.

504. Advanced Method in Graphic Processes (3) Exploration through laboratory experience of printing method: etching, silk screen, linoleum, or other; applications in teaching.

505. Foundations of Art Education (3) An examination of classic theories in art education and their relevance to current developments.

514. Functional Relationships in Crafts (3) Relationships of material design and purpose in crafts discussed by means of outstanding products of different materials, periods, and cultures. Prerequisites: 6 credits in crafts, or 3 in design and 3 in advanced crafts.

516. Analysis of Three-Dimensional Processes in Art (3) Three-dimensional processes analyzed with regard to kinetic, textural, form, and other functions.

520. Advanced Ceramic Art (3) Intensified exploration of throwing, glazing, and firing processes as related to aesthetic considerations in contemporary art forms and past cultures. Prerequisite: A ED 420.

535. Arts Administration for Schools and Colleges (3) Responsibilities of arts administrators in schools and colleges: program, staff development, supervision, facilities, financing, community relations, governance, and report writing.

536. Curriculum Development in Art Education (3) Factors affecting art curriculum decisions, analysis, selection, organization, preparation of curriculum. Evaluation and sources of art curriculum improvement and innovation. Prerequisites: 6 credits of methods.

541. Theories of Child Art (3) Study of current theories of child art; application of recent psychological and anthropological theories to understanding child art. Prerequisite: A ED 486 or 501.

545. Evaluation and Assessment in Art Education (3) Study of theories of evaluation; application of judgmental criteria; analysis and construction of assessment instruments and scoring procedures. Prerequisites: A ED 490, 501.

588. History of Art Education (3) Historical development of philosophies in art education in the United States and abroad.

589. Research Methods in Art Education (3-6) Orientation in research methods; findings and designs related to the study of problems in art education.

590. Colloquium (1-3)

595. Research in Art Education (1-6) Independent research, under an adviser, to be terminated by a scholarly report proportionately comparable in quality to a master's thesis. Prerequisites: 15 credits in art education at the 400 and 500 levels, including A ED 589.

602. Supervised Experience in College Teaching (1-3 per semester, maximum of 6)

ART HISTORY (ART H)

HELLMUT W. HAGER, *Head of the Department*
229 Arts II Building
814-865-6326

Degrees Conferred: Ph.D., M.A.

Senior Members of the Graduate Faculty
Anthony Cutler, Ph.D. (Emory) *Professor of Art History*
Roland Fleischer, Ph.D. (Johns Hopkins) *Professor of Art History*
Hellmut Hager, Ph.D. (Universität Bonn) *Professor of Art History*
Heinz Henisch, Ph.D. (Reading) *Professor of the History of Photography*
George Mauner, Ph.D. (Columbia) *Professor of Art History*
Jeanne Chenault Porter, Ph.D. (Michigan) *Associate Professor of Art History*
Elizabeth Smith, Ph.D. (NYU-Institute of Fine Arts) *Assistant Professor of Art History*
Elizabeth Walters, Ph.D. (NYU-Institute of Fine Arts) *Assistant Professor of Art History*

Graduate work is offered in the following areas: Ancient art, Medieval and Byzantine art, Renaissance and Baroque art, Modern art, and the history of photography. Special research opportunities are available through the Center for the Study of Renaissance and Baroque Art, an area of concentration within the art history department.

Admission Requirements

Scores from the Graduate Record Examination (GRE) Aptitude Test (verbal, quantitative, and analytical) are required for admission to the Department of Art History. Special emphasis will be given to the verbal part of the GRE scores. Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin*.

Candidates with a 3.00 junior-senior grade-point average and a minimum of 21 credits in art history will be considered for admission to the master's program. Lacking these, a promising candidate may be accepted on condition that deficiencies be remedied, but without graduate degree credit. The best-qualified applicants will be accepted up to the number of spaces that are available for new students.

Master's Degree Requirements

Candidates for the M.A. degree are required to complete a minimum total of 45 credits, including course work in the four major areas of art-historical study (Ancient, Byzantine-Medieval, Renaissance-Baroque, Modern) and a master's thesis. In addition, candidates must demonstrate a reading knowledge of two foreign languages, one of which must be German. The other language is normally French or Italian. Reading knowledge of one of these languages must be demonstrated before the end of three semesters of study. These regulations apply equally to Ph.D. students. For those students who want to enter the doctoral program and have already completed a master's degree from another university, a reading knowledge of one foreign language will be required before the student can be considered for admission to the department.

A combined M.A./Ph.D. candidacy examination must be passed with a grade of at least "B" for M.A. students, and a grade of "A" is required for acceptance to Ph.D. candidacy. Passing the examination may be accomplished anytime before receiving the M.A. degree.

Doctoral Degree Requirements

Twenty-four additional credits in art history courses, not including doctoral dissertation research, are required for the Ph.D. At the discretion of the candidate's departmental committee, the candidate may be required to take additional specialized courses pertaining to his or her major area of study. For the Ph.D., a written comprehensive examination and a final oral examination must be successfully completed in addition to the student's doctoral dissertation.

Student Aid

Graduate assistantships available to students in this program and other forms of student aid are described in the STUDENT AID section of the *Graduate Bulletin*.

ART HISTORY (ART H)

401. Studies in Greek Art (3-9)
402. The Illuminated Manuscript (3)
404. The Art of Colonial America (3)
405. Pioneers of Modern Architecture (3-6)
410. Taste and Criticism in Art (3)
411. Roman Art (3-9)
412. The Gothic Cathedral (3)
414. Italian Baroque Painting (3)
415. The Skyscraper (3)
416. American Painting: 1876-1913 (3)
421. Etruscan Art (3)
422. Studies in Medieval Sculpture (3-9)
423. Studies in Italian Renaissance Art (3-9)
424. Masters of Northern Baroque Art (3)
430. Goya and His Times (3)
432. Problems in Iconology (3-9)
435. Studies in Modern Art (3-6)
442. Early Christian Art (3)
450. The History of Photography (3)
452. Byzantine Art (3)
454. Spanish Baroque Art (3)
456. Gian Lorenzo Bernini and the Architecture of the Full Baroque in Rome (3)
458. Roman Rococo Architecture and the Dawn of Neoclassicism (3)

464. French Baroque Painting (3)
496. Independent Studies (1-18)
497. Special Topics (1-9)

510. Studies in Art History (3-6 per semester) Original investigation in art history, to be pursued independently or concurrently with course work in particular fields.

511. Seminar in Ancient Art (3-12) Selected topics from the history of Greek and Roman art.

512. Seminar in Medieval Art (3-12) Original research into problems dealing with the art of the Middle Ages.

513. Seminar in Renaissance Art (3-12) Investigations in the area of Renaissance art, centering around major masters and monuments.

514. Seminar in Baroque Art (3-12) Investigations in the area of baroque art, centering around major masters and monuments.

515. Seminar in Modern Art (3-12) Lectures, readings, reports, and discussions in the field of modern art.

517. Seminar in Eighteenth-Century Art (3-12) Investigation into themes and problems dealing with eighteenth-century art.

520. Seminar in Spanish Baroque Painting (1-6) Specific problems in the history of seventeenth-century Spanish painting.

522. Seminar in Byzantine Art (3-12) Specific iconographical and stylistic problems in Byzantine art and its relation to classical antiquity, the medieval West, and Islam.

525. Seminar in Modern Architecture (3-12) Investigation into the works and problems of modern architecture as they relate to the culture of our times.

542. The Illustration of the Apocalypse (3-6) Studies in the illustration of the Apocalypse, iconographical and stylistic, from the early Christian period through Dürer.

551. Historiography of Art History (1-6) The relationship between the definition of, and aproach to, art-historical problems from Vasari to the present.

552. Problems in Connoisseurship (3) A study of the problems of authenticating, attributing, and dating paintings and sculpture through internal evidence.

555. Art History Field Seminar (3-12) Investigations based on the site study of specific art objects, with trips in successive years to different art centers.

596. Individual Studies (1-9)

597. Special Topics (1-9)

602. Supervised Experience in College Teaching (1-3 per semester, maximum of 6)

ASTRONOMY (ASTRO)

SATOSHI MATSUSHIMA, *Head of the Department*
525 Davey Laboratory
814-865-0418

Degrees Conferred: Ph.D., M.S.

Senior Members of the Graduate Faculty
Eric D. Feigelson, Ph.D. (Harvard) *Associate Professor of Astronomy*
Gordon P. Garmire, Ph.D. (MIT) *Professor of Astronomy*
Satoshi Matsushima, D.Sc. (Tokyo) *Professor of Astronomy*
Peter I. Mészáros, Ph.D. (California-Berkeley) *Professor of Astronomy*
Lawrence W. Ramsey, Ph.D. (Indiana) *Associate Professor of Astronomy*
Douglas H. Sampson, Ph.D. (Yale) *Professor of Astrophysics*
Peter D. Usher, Ph.D. (Harvard) *Professor of Astronomy*
Daniel W. Weedman, Ph.D. (Wisconsin) *Professor of Astronomy*

Associate Member of the Graduate Faculty
John A. Nousek, Ph.D. (Wisconsin) *Research Associate; Assistant Professor of Astronomy*

Graduate instruction and research opportunities are available in both theoretical and observational astronomy and astrophysics. Currently active areas of theoretical research include atomic processes and radiative transfer, statistical astronomy, high-energy astrophysics including theory of neutron stars, black holes, compact objects, accretion shock dynamics, and relativity and cosmology. Observational areas include spectroscopic, photometric, and radio frequency observations of quasars and galaxies; complementary radio and X-ray studies of active galaxies and young stars; high-resolution spectroscopy of early- and late-type stars, peculiar stars, variable stars, and stellar activity phenomena; satellite observations of ultraviolet and X-ray spectra of stars and galactic sources; X-ray data from HEAO-1 and the Einstein Observatory on galactic and extragalactic X-ray sources and the diffuse X-ray background; sounding rocket and satellite instrumentation of X-ray and EUV telescopes and detectors; and electronic and computer instrumentation.

The center of observational research facilities is the Penn State Black Moshannon Observatory, located twenty-five miles northwest of the University Park Campus. Basic instruments are a telescope of 1.6m aperture and a variety of spectrographs equipped with modern detectors and data acquisition systems. Supplementing the local facilities, national facilities such as Kitt Peak, Cerro Tololo, Sacramento Peak, Hale, and the NRAO Very Large Array, as well as HEAO-1, IUE, and Einstein satellite observatories, and various national supercomputing centers, are used extensively by Penn State faculty and graduate students.

Admission Requirements
Scores from the Graduate Record Examination (GRE), including the advanced test, are required for admission. Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin*.

Applicants with a bachelor's degree in astronomy or an allied field such as physics, mathematics, or geophysics are given equal consideration for admission. Opportunity to make up possible undergraduate deficiencies is provided. A grade-point average of 3.00 or better for junior-senior courses in astronomy and related subjects is necessary for consideration for admission. Exceptions to these minimum requirements may be made for students with special backgrounds, abilities, and interests.

Degree Requirements
A nonthesis option is available for the M.S. degree.

Because modern astronomy has very close ties with mathematics, physics, and engineering, the program required of a doctoral candidate normally includes some courses in these related fields, in addition to those in astronomy. Proficiency in French, German, or Russian is required. A knowledge of computer programming may be substituted for the foreign language requirement.

Student Aid
Graduate assistantships available to students in this program and other forms of student aid are described in the STUDENT AID section of the *Graduate Bulletin*.

ASTRONOMY (ASTRO)

440. Introduction to Astrophysics (3)
450. Practical Astronomy (3)
460. Fundamentals of Celestial Mechanics (3)
480. Nebulae, Galaxies, and Cosmology (3)
485. Introduction to High-Energy Astronomy (3)
492. (AERSP 492, E E 492) Space Astronomy and Introduction to Space Science (3)
496. Independent Studies (1-18)
497. Special Topics (1-9)

510. Astrophysics (3) The theory of atomic structure and spectra and the theory of equilibrium statistical mechanics with applications to astrophysical plasmas. Prerequisite: PHYS 410.

513. Observational Techniques in Astronomy (3) Theoretical and practical aspects of modern observational astrophysics. Photometry, spectroscopy, stellar classification, detectors, space astronomy, and basic information theory. Prerequisite: ASTRO 440.

514. Observational Practice (1-3) Practical experience with the observational research facilities, and with techniques of data acquisition and reduction.

524. Celestial Mechanics and Spherical Astronomy (3) Two-body and one-body theory, elliptic motion, expansions, two-body orbit in space, coordinate transformations, planetary equations, Lagrange and Hamilton mechanics. Prerequisite: ASTRO 460.

528. Radiation Processes in Astrophysics (3) General processes of importance in high-energy, radio, and UV-optical-IR astronomy. Emphasis on physical principles of continuum processes. Prerequisite: PHYS 400.

530. Theory of Stellar Atmospheres (3) Theory of photospheric structure, radiative processes, and line-formation in the outer layers of stars, and interpretation of stellar spectra. Prerequisite: ASTRO 510.

531. Theory and Analysis of Spectral Lines (3) The formation of spectral lines for both the LTE and NLTE cases, analysis of both line profiles and integrated intensities. Prerequisite: ASTRO 530.

534. Stellar Structure and Evolution (3) Theory of physical processes, structure, and evolutionary changes of stars; nature of intrinsic variable stars; the Hertzsprung-Russell diagram. Prerequisite: ASTRO 510 or PHYS 561.

540. Galactic Astronomy (3) Phenomenological investigations of the interstellar medium and star formation; the structure, dynamics, and evolution of our and other normal galaxies. Prerequisite: ASTRO 440.

542. Gaseous Nebulae and Interstellar Matter (3) Theory and observations of galactic nebulae and interstellar medium, and problems related to the formation of stars. Prerequisite: ASTRO 510.

550. High-Energy Astrophysics (3) Theory and observations of X-rays and gamma rays from stars, black holes, neutron stars, supernova remnants, and extragalactic objects. Prerequisites: PHYS 400; PHYS 410 or 454.

582. Radio Astronomy (3) Methods of radio astronomy and its contribution to modern astrophysics. Galactic and extragalactic sources, using line, continuum, and interferometric observations. Prerequisite: ASTRO 440.

583. Galaxies, Quasars, and Cosmology (3) Structure and population of the Milky Way galaxy, properties of galaxies, properties and nature of quasars, distance scale, and deacceleration parameter. Prerequisite: ASTRO 582.

590. Colloquium (1-3) Continuing seminars which consist of a series of individual lectures by faculty, students, or outside speakers.

596. Individual Studies (1-9)

597. Special Topics (1-9)

602. Supervised Experience in College Teaching (1-3 per semester, maximum of 6)

BIOCHEMISTRY (BIOCH)

ALLEN T. PHILLIPS, *In Charge of Graduate Programs in Biochemistry*
408 Althouse Laboratory
814-865-1247

Degrees Conferred: Ph.D., M.S.

Senior Members of the Graduate Faculty
Nathan N. Aronson, Jr., Ph.D. (Duke) *Professor of Biochemistry*
Robert W. Bernlohr, Ph.D. (Ohio State) *Professor of Biochemistry*
Roy H. Hammerstedt, Ph.D. (Minnesota) *Professor of Biochemistry*
Ross C. Hardison, Ph.D. (Iowa) *Associate Professor of Biochemistry*
Wesley C. Hymer, Ph.D. (Wisconsin) *Professor of Biochemistry*
Kenneth A. Johnson, Ph.D. (Wisconsin) *Professor of Biochemistry*
Walter W. Karakawa, Ph.D. (Iowa) *Associate Professor of Biochemistry*
Richard L. McCarl, Ph.D. (Penn State) *Professor of Biochemistry*
John H. Pazur, Ph.D. (Iowa State) *Professor of Biochemistry*
Allen T. Phillips, Ph.D. (Michigan State) *Professor of Biochemistry*
Chen-Pei David Tu, Ph.D. (Cornell) *Associate Professor of Biochemistry and Molecular Biology*
Frederick C. Wedler, Ph.D. (Northwestern) *Professor of Biochemistry*

Associate Member of the Graduate Faculty
Ming Tien, Ph.D. (Michigan State) *Assistant Professor of Biochemistry*

The graduate program in Biochemistry provides training for students in the principal areas of modern biochemistry and concurrently allows each student to develop expertise in a specific area of research plus acquire teaching experience at the undergraduate level. The program includes opportunities for research in intermediary metabolism and cellular control mechanisms, biochemical genetics, enzyme structure, kinetics and mechanisms, biochemical endocrinology, glycoprotein metabolism, microfilament structure and assembly, membrane biochemistry, heart cell culture, biochemistry of reproduction, mammalian gene structure, transposable elements and plasmids, immunochemistry and structure of cell surface antigens. Facilities for these research areas are extensive and permit investigations that are at the forefront of current biochemical research.

Because the Biochemistry graduate program is associated administratively with the graduate programs in Microbiology and Molecular and Cell Biology, interaction with these areas is frequent through joint seminar programs, common research interests, and shared facilities for research.

Admission Requirements
Scores on the Graduate Record Examination (GRE) Aptitude Test (verbal, quantitative, and analytical) are normally required for admission. Only under exceptional circumstances will an application be considered without these scores. Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin*.

Admission to the program is competitive and is based on evaluations by the admissions committee of the applicant's performance in other degree programs, of GRE scores, an interview, and personal recommendations. Admission is normally made directly to the doctoral program although a master's degree is sometimes obtained on the way to the Ph.D. degree.

Entering graduate students are expected to have had the equivalent of one year's work in each of the following: general chemistry, analytical chemistry, organic chemistry, physical chemistry, general physics, calculus, and biology. Students with limited deficiencies in these subjects may be admitted but must make up such deficiencies concurrently with their graduate studies. Undergraduate courses in biochemistry and a foreign language are desirable but are not required for admission.

Master's Degree Requirements
Students who want to obtain the M.S. degree in Biochemistry must meet the minimum requirements set forth by the Graduate School. In addition, students are required to pass 12 credits at the 500 level, 6 of which must be in biochemistry courses plus 1 credit of seminar. For this degree, all students must submit a thesis and defend it before a committee of the faculty. The research must represent an original contribution to biochemical knowledge, and the time allotted to it is generally equivalent to about two years of full-time work.

Doctoral Degree Requirements

The Ph.D. program is designed to train independent research workers and scholars. Therefore, the research leading to a Ph.D. thesis is of fundamental importance to the training program. In addition to an intensive research experience, usually two to three years of laboratory work, students are required to complete the 9-credit sequence in biochemistry at the 500 level; 12 credits outside the program at the 400 and 500 levels; and 3 credits of seminar. Students also are required to know one foreign language pertinent to biochemistry and equivalent to one year's study at the college level.

A decision regarding certification of the student for candidacy in the Ph.D. program is usually made soon after the student has completed 30 credits of course and thesis work. Certification is based on faculty recommendations, academic performance, teaching performance, and satisfactory completion of a written qualifying examination.

A comprehensive examination is administered by the student's doctoral committee usually within three semesters after the student is admitted to candidacy. This examination consists of a written and an oral component, both of which primarily emphasize knowledge in areas pertaining to the thesis problem.

The faculty in Biochemistry also require each student to demonstrate the ability to collect, organize, and present the results obtained by research. This can be accomplished by earning an M.S. degree in which a formal master's thesis is prepared, by preparing a manuscript written primarily by the student and submitting it for publication in a refereed journal, or by presenting research findings at a national scientific meeting, the research for which must have been done by the student while enrolled in the graduate program. The choice between these alternatives is made in consultation with the thesis adviser.

Other Relevant Information

Entering students participate in course work in common with students in the Microbiology and Molecular and Cell Biology graduate programs to ensure that a solid foundation in relevant subjects is acquired. The choice of a research adviser is based on mutual research interests developed from rotations through research projects in two or three faculty laboratories before a specific adviser and topic are selected. Until students have chosen a research adviser, they are guided in selecting appropriate courses and in other matters by the general graduate adviser.

Student Aid

Graduate assistantships available to students in this program and other forms of student aid are described in the STUDENT AID section of the *Graduate Bulletin*. Under normal circumstances, all students admitted to the program and continuing in good standing are provided with graduate assistantship support from University sources and research grants.

BIOCHEMISTRY (BIOCH)

401. General Biochemistry (3)
402. General Biochemistry (3)
403. Experimental Biochemistry (4)
417. Biochemical Methods (4)
425. Introductory Physical Biochemistry (4)
437. Physiological Biochemistry (3)
451. Senior Seminar (1)
496. Independent Studies (1-18)
497. Special Topics (1-9)

503. Biochemical Problems (1-10 per semester) Prosecution of an assigned problem under the guidance of an instructor.

507. Seminar in Biochemistry (1 per semester)

514. (M C B 514) Molecular Biology and Cellular Regulation (3) Structure, synthesis, and biochemical properties of nucleic acids; protein biosynthesis; control of gene expression; molecular genetics. Prerequisite: BIOCH 402.

520. Carbohydrates, Lipids, and Their Integrated Metabolism (3) Chemistry of carbohydrates, lipids, and membranes; interrelationships between lipid and carbohydrate biosynthesis and metabolism. Prerequisite: BIOCH 402.

525. Proteins and Enzymes (3) Properties of proteins and polypeptides, structural analysis and molecular interactions; enzyme structure, kinetic mechanisms, and control. Prerequisite: BIOCH 402.

590. Colloquium (1-3)

597. Special Topics (1-9)

602. Supervised Experience in College Teaching (1-3 per semester, maximum of 6)

BIOENGINEERING (BIOE)

K. KIRK SHUNG, *Acting Chair of the Program Committee in Bioengineering*
233 Engineering Lab/Office Building
814-865-1407

Degrees Conferred: Ph.D., M.S.

Senior Members of the Graduate Faculty
William S. Adams, Ph.D. (Penn State) *Professor of Electrical Engineering*
Elsworth R. Buskirk, Ph.D. (Minnesota) *Professor of Applied Physiology*
Steven J. Fonash, Ph.D. (Pennsylvania) *Professor of Engineering Science*
Andris Freivalds, Ph.D. (Michigan) *Associate Professor of Industrial Engineering*
Roger P. Gaumond, D.Sc. (Washington) *Associate Professor of Bioengineering*
David B. Geselowitz, Ph.D. (Pennsylvania) *Professor of Bioengineering and Medicine*
Theodore M. Hollis, Ph.D. (Ohio State) *Professor of Biology*
Edward S. Kenney, Ph.D. (Penn State) *Professor of Nuclear Engineering*
Donald E. Kline, Ph.D. (Penn State) *Professor Emeritus of Materials Science*
William S. Pierce, M.D. (Pennsylvania) *Professor of Surgery*
M. G. Sharma, Ph.D. (Penn State) *Professor of Engineering Mechanics*
K. Kirk Shung, Ph.D. (Washington) *Associate Professor of Bioengineering*
John M. Tarbell, Ph.D. (Delaware) *Professor of Chemical Engineering*
James S. Ultman, Ph.D. (Delaware) *Professor of Chemical Engineering*
William A. Weidner, M.D. (Wisconsin) *Professor of Radiology*
Robert F. Zelis, M.D. (Chicago) *Professor of Medicine and Physiology*

Associate Members of the Graduate Faculty
Joseph J. McInerney, Ph.D. (Penn State) *Assistant Professor of Medicine and Bioengineering*
Gerson Rosenberg, Ph.D. (Penn State) *Associate Professor of Bioengineering and Senior Research Associate in Surgery*
Uri Tsach, Ph.D. (MIT) *Assistant Professor of Mechanical Engineering*

This intercollege program is designed to provide the student with graduate-level training in engineering and in the life sciences, and specialized training in specific areas of interaction of engineering with biology and medicine. Graduate instruction in bioengineering is under the direction of a program committee composed of graduate faculty representing several departments.

Opportunities for specialized research include electrical, mechanical, and ultrasonic properties of biological materials, development of an artificial heart, hemodynamics, electrocardiography, medical imaging, auditory electrophysiology, lung mechanics and pulmonary function, bioinstrumentation, transducers, and ultrasonics. Extensive computer facilities and specialized equipment are available to support these research activities.

Admission Requirements
Scores from the Graduate Record Examination (GRE) are required for admission. However, a student may be admitted provisionally for graduate study in a program without these scores. Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin.*

Students with a degree in engineering, physics, or the life sciences will be eligible for admission. All students must have a strong background in physics and mathematics. This background should include 6 credits in chemistry, 9 credits in calculus-based physics, and mathematics through calculus and differential equations. Students who lack one or two courses may still be considered for admission but will have to make up any deficiency early in their graduate program. Students with a 2.80

junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces available. Exceptions to the minimum grade-point average may be made for students with special backgrounds, abilities, and interests.

Master's Degree Requirements

The particular course of study depends on the student's background and area of research specialization. Courses are selected from the life sciences, engineering, and bioengineering. Course requirements include BIOE 401, 402, and 403 plus two 500-level courses in bioengineering, 6 credits in the life sciences (including BIOL 472), and 6 credits in technically oriented courses outside bioengineering and the life sciences. In addition, students without a previous degree in engineering or physics are required to complete up to 24 additional credits in engineering. Most of this additional course work will be at the undergraduate level and typically includes statics and dynamics, electric circuits and fields, electronic devices, fluid mechanics, and linear systems.

A thesis is required for the M.S. degree.

Continuous registration is required for all graduate students until the thesis is approved.

Doctoral Degree Requirements

Candidates for the Ph.D. degree generally are expected to complete PHSIO (BIOL) 571-572 plus several additional courses in the life sciences, five courses in bioengineering, and five graduate-level courses in engineering, mathematics, and physics. Supporting courses are available at University Park and The Milton S. Hershey Medical Center in anatomy, biochemistry, biology, biophysics, chemistry, laboratory animal medicine, materials science, mathematics, physics, physiology, and the engineering departments.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by demonstrating intermediate knowledge of an acceptable foreign language, or by taking an advanced technical writing course and presenting a formal proposal for thesis research to the doctoral committee.

Continuous registration is required for all graduate students until the thesis is approved.

Student Aid

Graduate assistantships available to students in this program and other forms of student aid are described in the STUDENT AID section of the *Graduate Bulletin*.

BIOENGINEERING (BIOE)

401. Introduction to Bioengineering (3)
402. Biomedical Instrumentation and Measurements (3)
403. Biomedical Instrumentation Laboratory (1)
496. Independent Studies (1-18)
497. Special Topics (1-9)

501. Bioengineering Transport Phenomena (3) Application of the equations of mass, energy, and momentum conservation to physiological phenomena and to the design of artificial organs.

502. Introduction to Bioelectric Phenomena (3) Electric phenomena in nerve and muscle, membrane potentials, Hodgkin-Huxley equations, volume conductor problem, applications to electrocardiography, electroencephalography, plethysmography.

503. Fluid Mechanics of Bioengineering Systems (3) Cardiovascular system and blood flow, non-Newtonian fluid description, vessel flows, unsteady flows and wave motion, windkessel theory, transmission line theory.

504. Physiological Systems Analysis (3) Application of systems theory, control theory, and analytic modeling strategies to the study of physiological systems. Prerequisites: BIOL 472, MATH 250.

505. Bioengineering Mechanics (3) Passive and active mechanical properties of tissues, rheological materials, models of muscle contraction, pulmonary mechanics, forces in muscular-skeletal system.

506. Medical Imaging (3) Medical diagnostic imaging techniques, including generation and detection of ultrasound, X-ray, and nuclear radiation; instrumentation and biological effects. Prerequisite: PHYS 202.

507. Bioengineering Applications of Laboratory Computers (3) The organization of small laboratory computers and their use in real-time analysis of physiological data. Prerequisites: BIOE 402, CMPSC 201.

552. (E MCH 552, I E 552) Mechanics of the Musculoskeletal System (3) Structure and biomechanics of bone, cartilage, and skeletal muscle; dynamics and control of musculoskeletal system models. Prerequisite: consent of program. Prerequisite or concurrent: BIOL 472.

553. (I E 553) Engineering of Human Work (3) Physics and physiology of humans at work; models of muscle strength; dynamic movements; neural control; physical work capacity; rest allocation. Prerequisite: BIOL 041 or 472.

570. Topics in Biomedical Instrumentation (1) Physiological basis, theory of operation, and practical aspects of clinical instrumentation.

580. Bioengineering Internship (3-6) Supervised experience at The Milton S. Hershey Medical Center, including rotation through services and work on a minor project. Prerequisites: BIOE 402; 3 credits in bioengineering at the 500 level.

596. Individual Studies (1-9)

597. Special Topics (1-9)

BIOLOGICAL CHEMISTRY (BCHEM)

EUGENE A. DAVIDSON, *Chair of the Department*
The Milton S. Hershey Medical Center
Hershey, PA 17033
717-534-8585

Degrees Conferred: Ph.D., M.S.

Senior Members of the Graduate Faculty
V. P. Bhavanandan, Ph.D. (Edinburgh) *Professor of Biological Chemistry*
Eugene A. Davidson, Ph.D. (Columbia) *Professor of Biological Chemistry*
Louis F. Hass, Ph.D. (Duke) *Associate Professor of Biological Chemistry*
Charles W. Hill, Ph.D. (Wisconsin) *Professor of Biological Chemistry*
Anita K. Hopper, Ph.D. (Illinois) *Professor of Biological Chemistry*
James E. Hopper, Ph.D. (Wisconsin) *Professor of Biological Chemistry*
Momcilo Miljkovic, Ph.D. (Eidg. Technische Hochschule, Zürich) *Associate Professor of Biological Chemistry*
George D. Rose, Ph.D. (Oregon State) *Professor of Biological Chemistry*
Cara-Lynne Schengrund, Ph.D. (Seton Hall) *Associate Professor of Biological Chemistry*
Ross Shiman, Ph.D. (California) *Professor of Biological Chemistry*

Associate Members of the Graduate Faculty
Ralph L. Keil, Ph.D. (Cornell) *Assistant Professor of Biological Chemistry*
Paul G. Szauter, Ph.D. (Washington) *Assistant Professor of Biological Chemistry*

Opportunities for research and graduate study are available in the chemistry and metabolism of complex polysaccharides, mechanism of enzymatic reactions, molecular biology, biochemistry of complex lipids, conformational analysis of carbohydrates and proteins, natural product chemistry, and physical chemistry of macromolecules.

The program is offered only at The Milton S. Hershey Medical Center.

Admission Requirements
Scores from the Graduate Record Examination (GRE) generally are required for admission. At the discretion of a graduate program, a student may be admitted provisionally for graduate study in a program without these scores. Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin*.

Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests. Interested students should contact the department chair.

Degree Requirements
The nonthesis option is available for the M.S. degree.

Student Aid
Graduate assistantships available to students in this program and other forms of student aid are described in the STUDENT AID section of the *Graduate Bulletin*.

BIOLOGICAL CHEMISTRY (BCHEM)

502. Biological Chemistry I (3) Structure-function relationships of macromolecules; pathways utilized for energy generation in mammalian systems; concepts of metabolic regulation.

503. (CMBIO 503, MICRO 503) Molecular Biology (3) Principles of molecular and microbial genetics; emphasis placed on experimental design toward problems in bacteria and lower eucaryotes. Prerequisite: BCHEM 502.

505. Biological Chemistry II (3) A continuation of BCHEM 502. Emphasis on interrelations of metabolic pathways, catabolic end products, and regulation. Prerequisite: BCHEM 502.

513. (CMBIO 513) Principles of Protein Structure (3) Review of thermodynamics; physical chemistry and architecture of globular proteins; predictive approaches; laboratory in computer modeling of three-dimensional structure.

520. (CMBIO 520) Genetic Analysis (3) Genetics of organisms most used in the analysis of problems in molecular biology: drosophila, yeast, and bacteria.

523. Metabolism (3) Molecular mechanisms employed by living systems to transform biological compounds, control production and utilization of energy, and regulate metabolic pathways.

528. (NEURO 528) Neurochemistry (3) Study at the molecular level of processes that permit cells of the central nervous system to perform their unique functions. Prerequisites: BCHEM 502, 505; PSIO 510 or NEURO 510.

533. Bioorganic Chemistry (3) A physical, chemical, and structural approach to the study of simple and complex compounds occurring in biological systems. Concurrent: BCHEM 502.

551. (CMBIO 551) Kinetics and Catalysis in Biochemical Systems (3) Information obtainable from steady-state and transient kinetic measurement on enzymes and cellular processes. Molecular basis for enzyme specificity and catalysis. Prerequisite: BCHEM 502.

553. Biochemical Techniques (3) Lectures and discussion on approaches to macromolecule and lipid separation and characterization; isolation of subcellular organelles; enzymatic assay; radioisotopes. Prerequisite: BCHEM 502.

590. Colloquium (1-3)

596. Individual Studies (1-9)

597. Special Topics (1-9)

BIOLOGY (BIOL)

208 Erwin W. Mueller Building
814-865-4562

Degrees Conferred: Ph.D., M.S.

Senior Members of the Graduate Faculty
Adam Anthony, Ph.D. (Chicago) *Professor of Zoology*
Edward D. Bellis, Ph.D. (Minnesota) *Professor of Biology*
Daniel Cosgrove, Ph.D. (Stanford) *Associate Professor of Biology*
William A. Dunson, Ph.D. (Michigan) *Professor of Biology*
Paul Grun, Ph.D. (Cornell) *Professor of Cytology and Cytogenetics*
Robert H. Hamilton, Ph.D. (Michigan State) *Professor of Biology*
Emerson Hibbard, Ph.D. (Michigan) *Professor of Biology*
Charles J. Hillson, Ph.D. (Penn State) *Professor of Botany*
Theodore M. Hollis, Ph.D. (Ohio State) *Professor of Biology*

Carl S. Keener, Ph.D. (North Carolina State) *Associate Professor of Biology*
David L. Pearson, Ph.D. (Washington) *Associate Professor of Biology*
Ronald A. Pursell, Ph.D (Florida State) *Professor of Botany*
Robert K. Selander, Ph.D. (Berkeley) *Eberly Professor of Biology*
Andrew G. Stephenson, Ph.D. (Michigan) *Professor of Biology*
C. Dale Therrien, Ph.D. (Texas) *Associate Professor of Biology*
Alfred Traverse, Ph.D. (Harvard) *Professor of Palynology*
Edward W. Wickersham, Ph.D. (Wisconsin) *Associate Professor of Biology*
Frederick M. Williams, Ph.D. (Yale) *Associate Professor of Biology*

Associate Members of the Graduate Faculty
Andrew G. Clark, Ph.D. (Stanford) *Associate Professor of Biology*
Robert B. Mitchell, Ph.D. (Penn State) *Associate Professor of Biology*
William H. Neff, Ph.D. (Penn State) *Associate Professor of Biology*
Christopher Uhl, Ph.D. (Michigan State) *Associate Professor of Biology*
Thomas S. Whittam, Ph.D. (Arizona) *Assistant Professor of Biology*

The department will direct graduate programs with specialization in cytology, cytochemistry, ecology, genetics, physiology, zoology, and other aspects of modern biology. The courses of study are planned individually by the student and an adviser.

Admission Requirements
Scores from the Graduate Record Examination (GRE) are required for admission. At the discretion of a graduate program, a student may be admitted provisionally for graduate study in a program without these scores. Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin*.

Admission is restricted to students who have the baccalaureate degree in a biological science and who present a cumulative undergraduate average of at least 3.00. Each applicant must provide a personal statement of interests and objectives and letters from three persons verifying the applicant's academic competence.

Master's Degree Requirements
Students who want to obtain an M.S. degree in Biology must complete 15 credits of course work, at least 6 of which should be at the 500 level. A thesis is usually required and must be defended before a faculty committee. The research must represent an original contribution, and the time allotted to it is about one year (12 to 15 credits).

Doctoral Degree Requirements
The Ph.D. program is planned by the student's Ph.D. committee after a written and oral candidacy examination is passed. The Ph.D. thesis must represent a significant original contribution and will usually require two or three years of laboratory or field research. An intermediate-level reading knowledge of one foreign language is required (equivalent to one year's study at the college level).

Student Aid
In addition to the fellowships, traineeships, graduate assistantships, and other forms of financial aid described in the STUDENT AID section of the *Graduate Bulletin,* the following award typically has been available to graduate students in this program:

National Institute of Aging Traineeships — Available to doctoral students in selected graduate programs for research training in adult development and aging; stipend varies. Details available from the Gerontology Center, S-211 Henderson Building.

BIOLOGY (BIOL)

402. Vertebrate Neuroanatomy (3)
407. Plant Anatomy (3)
409. Biology of Aging (3)
414. Taxonomy of Seed Plants (3)
417. Invertebrate Zoology (4)
418. Mycology (4)
420. (GEOSC 420) Paleobotany (3)
421. Comparative Anatomy of Vertebrates (4)
422. Advanced Genetics (3)

423. (GEOSC 423) Introductory Palynology (4)
426. Introductory Cytogenetics (3)
427. (GEOSC 427) Evolution (3)
428. Population Genetics (3)
431. Comparative Plant Morphology (2)
432. Laboratory in Comparative Plant Morphology (2)
433. Terrestrial Ecology (3)
434. Terrestrial Ecology Laboratory (3)
435. Ecology of Lakes and Streams (3)
437. Histology (4)
438. Ornithology (2)
439. Ornithology Laboratory (2)
440. Embryology (4)
441. Plant Physiology (3)
442. Plant Physiology (3)
446. Physiological Ecology (3)
447. Taxonomy of Mosses and Ferns (3)
448. Ecology of Plant Reproduction (3)
450. Experimental Field Biology (5)
452. Ichthyology (3)
454. Herpetology (2)
464. (ANTH 464) Sociobiology (3)
465. General Cytology (3)
466. Laboratory in Cytology (1)
467. Cytochemical Methods (3)
472. Mammalian Physiology (3)
473. Laboratory in Mammalian Physiology (2)
477. Biology of Human Sexuality (3)
479. General Endocrinology (3)
482. Coastal Biology (4)
496. Independent Studies (1-18)
497. Special Topics (1-9)

502. The Physiology of the Fungi (3) Chemical composition, metabolism, toxic and stimulating agencies, spore germination, growth and irritability of the fungi.

504. (M C B 504) Seminar in Cell Biology (1) Discussion of current problems and ideas in cell biology, with emphasis on reference to recent literature.

506. Comparative Anatomy of Vascular Plants (2) Structure of the Tracheophyta from a phylogenetic standpoint. Prerequisite or concurrent: BIOL 407.

511. Advanced Plant Physiology (3) Physiology of plants, including uptake of water and minerals, translocations, mineral nutrition, energy relations, respiration, and catabolism. Prerequisite: BIOL 442.

512. Advanced Plant Physiology (3) Continuation of BIOL 511. Physiology of plants, including photosynthesis, synthesis of cellular constituents, growth and development. Prerequisite: BIOL 442.

514. Topics in Plant Systematics and Evolution (1) Discussion of pertinent current literature in plant biosystematics.

518. Special Problems (1-6) Prosecution of an assigned problem under the guidance of a staff member. Throughout the year as arranged. By appointment.

519. Zoogeography (3) The present distribution of world vertebrates, their evolution, and their patterns of dispersal in the past.

522. Lower Fungi (3) Morphology, taxonomy, phylogeny, and life histories. Prerequisite: BIOL 418.

523. Higher Fungi (3) Morphology, taxonomy, phylogeny, and life histories. Prerequisite: BIOL 418.

524. Seminar in Genetics (1 per semester)

526. (GEOL 526) Problems in Palynology (1-6) Individual research projects in various aspects of palynology, especially palynostratigraphy and paleoecological palynology. Prerequisite: BIOL 423.

527. (STAT 527) Quantitative Ecology (3) Introduction to quantitative population and community ecology, with emphasis on problems, concepts, and methods using mathematical, statistical, and computational analysis. Prerequisites: BIOL 210, STAT (MATH) 409.

528. (STAT 528) Statistical Ecology Spectrum (3) Overview of research and instruction of particular interest to quantitative ecology faculty in the Ecology program. Prerequisite: BIOL (STAT) 527.

533. Problems in Genetics (2-6) Problems to suit needs of individual students; conferences and laboratory work.

535. Morphology of the Tracheophyta Exclusive of Angiosperms (3) Origin, developmental tendencies, structure, and paleobotanical evidence.

536. Morphology of Angiosperms (3) Floral origin and development, fertilization, embryogeny, seeds and fruit development. Prerequisite: BIOL 431.

538. Principles of Microscopic Histochemistry (2) Theoretical basis for the microscopic identification, localization, and quantitative analysis of chemical substances in tissues of organisms. Prerequisite: BIOL 437 or 465.

539. Analytical Histochemistry Laboratory (2-4) Application of histochemical techniques in the microscopic analysis of tissue lipids, proteins, carbohydrates, nucleic acids, and proteins. Prerequisite or concurrent: BIOL 538.

540. Phycology (4) Comparative morphology, taxonomy, and ecology of freshwater and marine algae; culturing, collection, preservation techniques.

542. (ENT 542, WILDL 542) Systematics (3) Principles and methods of classification, phylogeny, and speciation; taxonomic techniques; analysis of species; causal interpretation of animal diversity.

544. Advanced Physiological Ecology (4) The physiological abilities of plants and animals to adapt to their abiotic environment.

545. Ecosystem Dynamics (3) Survey and discussion of recent literature on ecosystem structure and function. Prerequisite: BIOL 210.

546. Ecology of Populations (3) Ecological responses of organisms to environmental variables (food, etc.) that determine population behavior. Demography, competition, predation, and community principles.

547. Invertebrate Biology (3) Embryological development, metamorphosis, regeneration, and endocrinology of selected invertebrate groups (insects excluded). Invertebrate interactions and ecological impact.

550. Neurogenesis (2) Embryonic and evolutionary development of the nervous system. Determination, differentiation, orientation, and specificity of growing and regenerating nerve cells. Prerequisite: BIOL 440.

571. (PHSIO 571) Animal Physiology (3) Mammalian cardiovascular, respiratory, renal, and gastrointestinal systems. Prerequisite: BIOL 472.

572. (PHSIO 572) Animal Physiology (3) Mammalian nervous, endocrine, metabolic, and reproductive systems. Prerequisite: BIOL 473.

582. (PTYSC 582, PSY 582) Research in Animal Behavior (2-6 per semester) Research in special areas of animal behavior involving field or laboratory work.

593. (ANTH 593, ENT 593, GEOSC 593, INTAG 593) Tropical Field Studies (Organization for Tropical Studies) (8) An intensive field course concentrating on field problems, experimental design, and data analysis in tropical habitats. Prerequisite: approval by the Committee on Tropical Studies.

BOTANY (BOT)

208 Erwin W. Mueller Building
814-865-4562

Degrees Conferred: Ph.D., M.S.

Senior Member of the Graduate Faculty
Daniel Cosgrove, Ph.D. (Stanford) *Associate Professor of Biology*
Paul Grun, Ph.D. (Cornell) *Professor of Cytology and Cytogenetics*
Robert H. Hamilton, Ph.D. (Michigan State) *Professor of Biology*
Charles J. Hillson, Ph.D. (Penn State) *Professor of Botany*
Carl S. Keener, Ph.D. (North Carolina State) *Associate Professor of Biology*
Ronald A. Pursell, Ph.D. (Florida State) *Professor of Botany*
Andrew G. Stephenson, Ph.D. (Michigan) *Professor of Biology*
C. Dale Therrien, Ph.D. (Texas) *Associate Professor of Biology*
Alfred Traverse, Ph.D. (Harvard) *Professor of Palynology*

Associate Member of the Graduate Faculty
Christopher Uhl, Ph.D. (Michigan State) *Associate Professor of Biology*

Botanical programs are offered in plant anatomy, bryology, cytology, ecology, genetics, morphology, mycology, paleobotany, palynology, physiology, and taxonomy.

See also Genetics and Plant Physiology.

For courses in Botany and related subjects see Biology.

Admission Requirements

Scores from the Graduate Record Examination (GRE) are required for admission. At the discretion of a graduate program, a student may be admitted provisionally for graduate study in a program without these scores. Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin*.

A student having a degree in science or in one of the biological sciences is eligible for admission. Entering graduate students should have had basic courses in chemistry, mathematics, and physics.

Admission is restricted to students who have the baccalaureate degree in a biological science and who present a cumulative undergraduate average of at least 3.00. Each applicant must provide a personal statement of interests and objectives and letters from three persons verifying the applicant's academic competence.

Master's Degree Requirements

Students who want to obtain an M.S. degree in Botany must complete 15 credits of course work, at least 6 of which should be at the 500 level. A thesis is usually required and must be defended before a faculty committee. The research must represent an original contribution, and the time allotted to it is about one year (12 to 15 credits).

Doctoral Degree Requirements

The Ph.D. program is planned by the student's Ph.D. committee after a written and oral candidacy examination is passed. The Ph.D. thesis must represent an original contribution and will usually require two or three years of laboratory or field research. An intermediate-level reading knowledge of one foreign language is required (equivalent to one year's study at the college level).

Student Aid

In addition to the fellowships, traineeships, graduate assistantships, and other forms of financial aid described in the STUDENT AID section of the *Graduate Bulletin*, the following awards typically have been available to graduate students in this program:

J. Ben and Helen D. Hill Memorial Fund Scholarship

Henry W. Popp Graduate Assistantship

BUSINESS ADMINISTRATION (B A)

MICHAEL P. HOTTENSTEIN, *Assistant Dean; Faculty Director of Graduate Programs in Business*
106 Business Administration Building
814-863-0474

Degrees Conferred: Ph.D., M.S., M.B.A.

Senior Members of the Graduate Faculty

W. Graham Astley, Ph.D. (Washington) *Associate Professor of Management*
John W. Bagby, Ph.D. (Tulsa) *Associate Professor of Business Law*
Peter D. Bennett, Ph.D. (Texas) *Professor of Marketing*
Stewart W. Bither, Ph.D. (Washington) *Professor of Marketing*
Daniel J. Brass, Ph.D. (Illinois) *Associate Professor of Organizational Behavior*
Joseph L. Carroll, D.B.A. (Indiana) *Professor of Business Logistics*
Joseph L. Cavinato, Ph.D. (Penn State) *Associate Professor of Business Logistics*
Kalyan Chatterjee, D.B.A. (Harvard) *Associate Professor of Management Science*
David P. Christy, Ph.D. (Georgia) *Assistant Professor of Management Science*
Philip L. Cochran, Ph.D. (Washington) *Associate Professor of Business Administration*
John J. Coyle, D.B.A. (Indiana) *Professor of Business Administration*
Anthony J. Curley, Ph.D. (Pennsylvania) *Professor of Finance*
Barry E. Cushing, Ph.D. (Michigan State) *Professor of Accounting and Management Information Systems*
Samuel G. Davis, Ph.D. (Syracuse) *Associate Professor of Management Science*
Mark W. Dirsmith, Ph.D. (Northwestern) *Price Waterhouse Auditing Professor*
Rodney Erickson, Ph.D. (Washington) *Professor of Business Administration*
Peter Everett, Ph.D. (North Carolina) *Associate Professor of Marketing*
J. Russell Ezzell, Ph.D. (Penn State) *Professor of Finance*
William L. Ferrara, Ph.D. (Michigan State) *Professor of Accounting*
Dennis A. Gioia, Ph.D. (Florida State) *Associate Professor of Organizational Behavior*
Barbara Gray, Ph.D. (Case Western Reserve) *Associate Professor of Organizational Behavior*
Paul S. Greenlaw, Ph.D. (Syracuse) *Professor of Management*
J. D. Hammond, Ph.D. (Pennsylvania) *William Elliott Professor of Insurance*
Terry P. Harrison, Ph.D. (Tennessee) *Assistant Professor of Management Science*
Jack C. Hayya, Ph.D. (UCLA) *Professor of Management Science*
George J. Heitmann, Ph.D. (Princeton) *Professor of Management Science*
Benjamin N. Henszey, M.L.T. (Georgetown) *Professor of Business Law*
Michael P. Hottenstein, D.B.A. (Indiana) *Professor of Management*
Stephen F. Jablonsky, Ph.D. (Illinois) *Associate Professor of Accounting and Management Information Systems*
Austin J. Jaffe, Ph.D. (Illinois) *Professor of Business Administration*
Eugene J. Kelley, Ph.D. (NYU) *Research Professor of Business Administration*
J. Edward Ketz, Ph.D. (Virginia Polytechnic) *Associate Professor of Accounting and Management Information Systems*
George B. Kleindorfer, Ph.D. (Carnegie-Mellon) *Associate Professor of Quantitative Business Analysis*
Ronald S. Koot, Ph.D. (Oregon) *Professor of Management Science*
Gary L. Lilien, D.E.S. (Columbia) *Research Professor of Management Science*
Kenneth M. Lusht, Ph.D. (Georgia State) *Professor of Business Administration*
Robert E. Malcom, Ph.D. (Ohio State) *Professor of Accounting and Management Information Systems*
James A. Miles, Ph.D. (Penn State) *Associate Professor of Finance*
James H. Miller, Ph.D. (Penn State) *Associate Professor of Business Logistics*
Valerie C. Milliron, Ph.D. (Southern California) *Assistant Professor of Accounting and Management Information Systems*
Kofi O. Nti, Ph.D. (Yale) *Associate Professor of Management Science*
Jerry C. Olson, Ph.D. (Purdue) *Professor of Marketing*
J. Keith Ord, Ph.D. (London) *Professor of Management Science and Statistics*
Robert D. Pashek, Ph.D. (Illinois) *Professor of Business Administration*
Srikanth Rao, Ph.D. (Penn State) *Associate Professor of Business Logistics*
Edward T. Reutzel, Ph.D. (Penn State) *Associate Professor of Management Science*
Paul H. Rigby, Ph.D. (Texas) *Professor of Business Administration*
William J. Schrader, Ph.D. (Washington) *Professor of Accounting and Management Information Systems*
Arnold F. Shapiro, Ph.D. (Pennsylvania) *Professor of Business Administration*
Henry P. Sims, Jr., Ph.D. (Michigan State) *Professor of Organizational Behavior*
Charles H. Smith, Ph.D. (Penn State) *Peat Marwick Professor of Accounting*
Charles C. Snow, Ph.D. (California) *Professor of Organizational Behavior*
John C. Spychalski, D.B.A. (Indiana) *Professor of Business Administration*
Alan J. Stenger, Ph.D. (Minnnesota) *Associate Professor of Business Logistics*

Harish Sujan, Ph.D. (UCLA) *Assistant Professor of Marketing*
Mita Sujan, Ph.D. (UCLA) *Assistant Professor of Marketing*
Gerald I. Susman, Ph.D. (UCLA) *Professor of Organizational Behavior*
James B. Thies, Ph.D. (Northwestern) *Associate Professor of Accounting and Management Information Systems*
Richard Twark, Ph.D. (Penn State) *Associate Professor of Quantitative Business Analysis*
John E. Tyworth, Ph.D. (Oregon) *Associate Professor of Business Logistics*
Steven L. Wartick, Ph.D. (Washington) *Assistant Professor of Business Administration*
David T. Wilson, Ph.D. (Western Ontario) *Professor of Marketing*
Robert A. Wood, Ph.D. (Pittsburgh) *Associate Professor of Finance*
J. Randall Woolridge, Ph.D. (Iowa) *Associate Professor of Finance*

Associate Members of the Graduate Faculty
Terry L. Campbell, D.B.A. (Indiana) *Assistant Professor of Accounting and Management Information Systems*
Kang-Rae Cho, Ph.D. (Washington) *Assistant Professor of International Business*
Robert P. Crum, Ph.D. (Kentucky) *Assistant Professor of Accounting*
James W. Dean, Ph.D. (Carnegie-Mellon) *Assistant Professor of Organizational Behavior*
Charles R. Enis, Ph.D. (Maryland) *Associate Professor of Accounting and Management Information Systems*
James R. Garven, Ph.D. (Illinois) *Assistant Professor of Finance*
Gary L. Gittings, Ph.D. (Penn State) *Assistant Professor of Business Logistics*
James B. Heian, Ph.D. (Utah) *Assistant Professor of Accounting and Management Information Systems*
Leon B. Hoshower, Ph.D. (Michigan State) *Assistant Professor of Accounting*
Robert W. Koehler, Ph.D. (Michigan State) *Associate Professor of Accounting*
Patrick S. Lee, Ph.D. (Carnegie-Mellon University) *Assistant Professor of Management Science*
H. LeRoy Marlow, Ed.D. (Cornell) *Professor of Management Development*
Carol J. McNair, Ph.D. (Columbia) *Assistant Professor of Accounting*
Eugene R. Melander, Ph.D. (Minnesota) *Professor of Quantitative Business Analysis*
Jeffrey E. Michelman, Ph.D. (Wisconsin) *Assistant Professor of Accounting and Management Information Systems*
R. William Millman, Ph.D. (Florida) *Professor of Business Administration*
Sanford Morton, Ph.D. (Carnegie Mellon) *Assistant Professor of Accounting*
Barry L. Myers, J.D. (Boston Law) *Associate Professor of Business Law*
Robert Novack, Ph.D. (Tennessee) *Assistant Professor of Business Logistics*
Reed T. Phalan, J.D. (Michigan Law) *Professor of Business Law*
Mark P. Sharfman, Ph.D. (Arizona) *Assistant Professor of Organization Theory*
Gary S. Shea, Ph.D. (Washington) *Assistant Professor of Finance*
Evelyn A. Thomchick, Ph.D. (Pennsylvania) *Assistant Professor of Business Logistics*
Daniel R. Toy, Ph.D. (Penn State) *Assistant Professor of Marketing*
Gautam Vora, Ph.D. (Indiana) *Assistant Professor of Finance*

The Master of Business Administration program is a professional degree designed to prepare individuals for managerial positions in business, government, and nonprofit institutions. The M.B.A. curriculum blends technical rigor, managerial theory, and integrative learning experiences through case studies and other teaching methods. A managerial communications course is fully integrated into the program.

The Master of Science in Business Administration program is highly flexible and designed for advanced study in a specialized field. The M.S. program is directed toward the development of competency within a defined area of management. Fields such as accounting, business logistics, finance, marketing, personnel, human resources management, management information systems, management science, and real estate are examples of career opportunities requiring specialized knowledge and skill, including research.

The Doctor of Philosophy in Business Administration program offers advanced graduate education for students contemplating careers in academic teaching and research and research in nonuniversity settings. The faculty of the college views the Ph.D. as evidencing scholarship at the highest level.

Admission Requirements
Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin*.

Applicants to any of the graduate programs in Business Administration are required to take the Graduate Management Admission Test (GMAT), which is administered by the Educational Testing Service four times a year. For dates, locations, and other information about the test, write for the *Bulletin of Information,* Graduate Management Admission Test, Educational Testing Service, Princeton, NJ 08540.

Criteria for evaluating applicants include professional and academic accomplishments, GMAT scores, recommendations, and personal data from application forms that provide indications of future academic and professional accomplishment.

Work on the M.B.A. degree may be started fall semester only. M.S. and Ph.D. candidates may begin either the fall or spring semester. Individuals from all undergraduate disciplines are encouraged to apply.

While admission to the doctoral program does not require the applicant to hold a master's degree, this is ordinarily the case.

Master's Degree Requirements

The M.B.A. program consists of two distinct portions: (1) preprogram competency expectations, including accounting, economics, mathematics, and statistics; and (2) 54 credits of graduate courses. Individuals who did not have adequate preparation in accounting, economics, mathematics, and statistics in their undergraduate programs can develop the required minimum level of competency through the use of self-teaching guides available through the graduate office in business administration. This competency must be developed before graduate study can begin. The time required to complete this graduate program, based on full-time study, is twenty-one months. The student body is divided into diverse sections of approximately forty students, with each section proceeding through the same core classes each semester. Emphasis is placed on student interaction and shared learning both inside and outside the classroom.

The M.S. program consists of two distinct portions: (1) approximately 33 acceptable undergraduate foundation credits in business administration, economics, and mathematics; and (2) 30 graduate credits in business administration or related areas, including a thesis. An applicant may be admitted without foundation courses, but they must be made up without degree credit. A professional paper and 6 additional credits of graduate-level course work can be substituted for the thesis. The time required to complete the graduate portion of this program, based on full-time study, is twelve months.

Doctoral Degree Requirements

Competency Expectations: Entrance into the doctoral program in business administration does not require the completion of an undergraduate degree specifically in business. While almost any major at the undergraduate level may be acceptable, graduate study in business administration does presume a minimum level of competency in mathematics, statistics, and computing. No transcript credit is required for entering doctoral candidates in these areas, except where specified by particular fields of specialization. However, it must be emphasized that lack of minimum competency in mathematics, statistics, and computing could significantly disadvantage the candidate.

Breadth Requirement: All candidates will develop a broad understanding of the functions of the business organization. To achieve breadth, all Ph.D. candidates must show competency by completing 12 credits of graduate course work in a minimum of two of the approved fields of study within the College of Business Administration and in economics. The 12 credits in the breadth requirement must be taken in fields outside or separate from a candidate's primary, supporting, and research competency fields.

Primary Field Requirements: All candidates are required to achieve competency in a primary field of business administration. The primary field is that sphere of scholarship that commands the most extensive and intensive portion of a program of study. This is the area in which the dissertation research and major professors are selected. Primary fields may be selected from the following: accounting, business logistics, finance, insurance, international business, management science/operations management, marketing, and organizational behavior.

Graduate work in a selected primary field may require competency in prerequisite areas including undergraduate work in the field itself as well as prior work in mathematics, statistics, computer science, economics, and social and behavioral sciences. The prerequisite work will be specified by each primary field.

Supporting Field Requirements: All candidates must select a supporting field of study from business administration or related outside areas. These spheres of scholarship complement the candidate's primary field. Supporting fields from business administration include all the primary fields. Outside supporting fields include, but are not limited to, anthropology, civil engineering, computer science, economics, industrial engineering, mathematics, political science, psychology, sociology, and statistics.

Research Methods Field: All candidates must develop a broad understanding of the scientific research process and in-depth competency in the methods of research employed in the primary field. Each candidate's doctoral committee shall specify a minimum of three graduate-level courses (beyond the M.B.A. core courses) to constitute a supporting field in research methods. One of these

courses must focus on the philosophy of science. Others should cover specific methods and tools relevant for research in the primary fields. A member of the doctoral committee shall be designated to represent the research methods field and shall be responsible for evaluating the candidate's competence in the field.

Language and Communication Requirements: All candidates must be competent in the English language and must have demonstrated skills in communicating ideas both orally and in writing commensurate with the requirements of scholarly and professional work. Competency in the English language for candidates whose native language is not English can be demonstrated as follows: (1) a score of 585 or better on the TOEFL combined with a score of 250 or better on the Test of Spoken English or (2) satisfactory performance in SPCOM 115G.

Satisfactory skills in communicating ideas shall be demonstrated by satisfactorily preparing and presenting a working paper for the faculty and peers in the primary field. The language and communication requirements must be satisfied before the scheduling of any portion of the comprehensive examination.

Other Relevant Information

The College of Business Administration, in cooperation with the Department of French, offers concurrent master's degree programs in French Studies and in Business Administration to provide training in both business and French studies for students who plan a career in international business. For details of the programs, see the description of the graduate program in French. The college also offers work/study abroad programs in France, Germany, and Peru.

Student Aid

In addition to the fellowships, traineeships, graduate assistantships, and other forms of financial aid described in the STUDENT AID section of the *Graduate Bulletin,* the following awards typically have been available to graduate students in this program:

American Accounting Association Fellowship — Available to a Ph.D. candidate in accounting; stipend variable up to $1,000 per year.

American Institute of Certified Public Accountants Fellowship — Available to a Ph.D. candidate in accounting; stipend variable up to $600 monthly, or $700 monthly with dependents (maximum of twelve months).

Arthur Anderson & Co. Foundation Fellowship — Available to a Ph.D. candidate in accounting; stipend variable up to $7,800 (distributed monthly — maximum of twelve months).

Arthur Young and Company Fellowship — Open to a master's degree candidate in accounting from a predominantly black college. Contact the department in the College of Business Administration.

Coopers & Lybrand Foundation Fellowship — Available to a Ph.D. candidate in accounting; stipend variable, up to $5,000.

Ernst and Whinney Fellowship — Available to a master's candidate in accounting, stipend $1,000; to a Ph.D. candidate with stipend up to $7,800 (distributed monthly — maximum of twelve months).

GTE Scholars — Sponsored by GTE for M.B.A. candidates who show academic and professional promise; $1,000 per year.

Haskins and Sells Foundation Fellowship — Available to a Ph.D. candidate in accounting after candidate's first academic year; stipend in two parts: $4,000 (last twelve months of course work) and $8,000 (twelve months during dissertation stage).

Mid-State Bank Scholarship — Endowed by Mid-State Bank for M.B.A. candidates with outstanding academic credentials whose official residence is in the bank's service area; tuition remission.

Mr. Charles Scholars — A merit-based cash award to a first-year M.B.A. student. Provided by Nick Petnick, a local businessman; $1,000.

Price Waterhouse Foundation Fellowship — Available to a Ph.D. candidate in accounting; stipend variable.

Shaeffer Scholars Program — Provided by Charles W. Shaeffer ('33), retired board chairman, T. Rowe Price Associates, to M.B.A. candidates evidencing strong academic and managerial potential. Tuition remission plus stipend. Apply to the director of the M.B.A. program.

ACCOUNTING (ACCTG)

400. Financial Accounting I (5)
401. Financial Accounting II (4)
403. Auditing (4)
404. Managerial Accounting (4)
406. Advanced Federal Taxation (3)
413. Auditing Internship (3)
414. Managerial Accounting Internship (3)
416. Federal Income Tax Form Preparation (1)
421. (I B 421) International Accounting (3)
496. Independent Studies (1-18)
497. Special Topics (1-9)

501. Research Methods in Accounting (3) An introduction to the methods and techniques of contemporary research in accounting. Prerequisites: ACCTG 504, 507, and a course in statistical inference.

503. Seminar in Auditing (3) The attest function of independent public accountants, verification of financial statements; problems of evidence, independence, ethics, professional responsibilities. Prerequisite: ACCTG 403.

504. Seminar in Managerial Accounting (3-6) Accounting and the managerial processes of planning, control, and decision making.

507. Seminar in Financial Accounting (3) Theoretical basis of financial accounting.

508. Contemporary Issues in Accounting (3) Selected problems of current interest to the accounting profession.

511. Financial and Managerial Accounting (3) Fundamental financial and managerial accounting concepts and issues from the viewpoint of the report user.

512. Financial Accounting Theory and Reporting Problems (3) Measurement and reporting of financial information for external purposes, with particular attention to current problems in asset and income measurement. Prerequisite: ACCTG 511.

514. Seminar in Federal Taxation (3) The federal tax structure, including legal, economic, and government implications; focusing on business decisions, research methodology, and tax planning.

515. Development of Accounting Thought (3) Development of accounting thought from ancient civilizations to the present.

516. Seminar in Not-for-Profit Accounting (3) Measurement and structuring of financial information for managerial planning and control and external reporting.

524. Managerial Accounting (3) Concepts and techniques of accounting for planning, control, and motivation. Prerequisite: ACCTG 511.

590. Colloquium (1-3)

596. Individual Studies (1-9)

597. Special Topics (1-9)

602. Supervised Experience in College Teaching (1-3 per semester, maximum of 6)

BUSINESS ADMINISTRATION (B A)

496. Independent Studies (1-18)
497. Special Topics (1-9)
499. Foreign Study — Business Administration (2-6)

503. Seminar in Public Utilities (3)

513. (PSY 513, PHIL 513) Principles and Methods of Empirical Science (3) Scientific methodologies and their presuppositions, with special emphasis on behavioral and social sciences. Prerequisite: doctoral candidacy in business administration or psychology or graduate status in philosophy.

517. Communication Skills for Management (1-3) Development of communication skills required for management; audience awareness, style, individual and group presentations. Prerequisite: admission to the Master of Business Administration program.

533. Prices and Markets (3) A survey of analytical concepts and techniques essential to an understanding of the business environment.

555. Business and Society (3) Evolution of the business organization and the changing framework of its operations, responsibilities, and social control.

560. Enterprise Consulting (3) Student groups engaging in consulting relationships with enterprises through use of managerial techniques for identification, analysis, and solution of managerial problems. Prerequisites: ACCTG 511; B A 533, 555; MGMT 501; Q B A 510, 511.

574. Business Research (1-3) A project paper, comparable in quality and scope of work to a graduate thesis, on problems of a company. Prerequisite: 15 credits of 400- and 500-level courses in business administration.

578. Entrepreneurship (3) Study of the development or acquisition of a business appropriate to the objectives and resources of the individual entrepreneur.

590. Colloquium (1-3)

596. Individual Studies (1-9)

597. Special Topics (1-9)

BUSINESS LAW (B LAW)

400. Real Estate Law (3)
410. Criminal Law and Procedure in the Business Community (3)
445. Business and Public Law (3)
471. (ADM J 471) Legal Rights, Duties, Liabilities of Criminal Justice (3)
473. (ADM J 473) Criminal Procedure and Evidence in the Business Community (3)
496. Independent Studies (1-18)
497. Special Topics (1-9)

BUSINESS LOGISTICS (B LOG)

400. Transport Planning Analysis (3)
405. Warehousing and Terminal Management (3)
410. Transport Economics and Policy (3)
415. Logistics Supply Management (3)
420. Urban Transportation (3)
425. Logistics Systems Management (3)
430. Transport Problems (3)
455. International Logistics (3)
496. Independent Studies (1-18)
497. Special Topics (1-9)

538. Logistics Systems Management (3) Control of the movement of goods; coordination of supply and demand in creation and maximization of time and place utility.

540. Transport Policy (3) Role of transport in the economy. Transport systems elements, development cost, and pricing characteristics. Public control and public policies.

541. Socioeconomic Analysis in Transportation (3) Role of transport in social and economic activity. Planning and coordination of transport systems. Designed for the traffic engineering program.

542. Logistics and Transport Planning (3) Techniques of analysis for public and private sector project and program decisions.

544. Logistics and Transport Management (3) Design of optimal strategies for transport and logistics systems management under varying internal and external conditions. Prerequisites: 6 credits in business logistics.

560. Seminar in Transport Economics and Policy (3 per semester, maximum of 6) Comparative analysis of theoretical and empirical studies in transport cost, demand, pricing, and policy problems.

565. Seminar in Business Logistics (3-6)

590. Colloquium (1-3)

596. Individual Studies (1-9)

597. Special Topics (1-9)

FINANCE (FIN)

405. Capital Budgeting (3)
406. Security Analysis and Portfolio Management (3)
408. Financial Markets (3)
410. Speculative Markets (3)
496. Independent Studies (1-18)
497. Special Topics (1-9)

504. Problems in Finance (3-6) Planned individual projects involving library, laboratory, or field work.

505. (I B 505) Multinational Managerial Finance (3) Analysis of the international aspects of managerial finance. Emphasis on the environmental and institutional factors influencing capital acquisition and allocation. Prerequisite: FIN 531.

506. Portfolio Theory and Policy (3) Rigorous examination and analysis of asset-holder behavior under conditions of risk and uncertainty.

508. Analysis of Financial Markets (3) Analysis of factors affecting price determination in financial markets.

510. Contemporary Issues in Financial Institutions (3) Critical investigation of problems of current interest in the market structure and internal operations of financial institutions.

531. Financial Management (3) An intensive examination of techniques available to aid the financial manager in decision making.

532. Financial Decision Processes (3) Financial decision making under uncertainty; positive and normative models and current issues in financial management.

541. Security Analysis (3) Discussion and application of analytical techniques in security valuation, including use of computers.

561. Seminar in Finance (3-6) Comparative analysis of research in the theories of finance; relationships to business management practices.

590. Colloquium (1-3)

596. Individual Studies (1-9)

597. Special Topics (1-9)

602. Supervised Experience in College Teaching (1-3 per semester, maximum of 6)

INSURANCE (INS)

400. Estate Planning (3)
401. Fundamentals of Private Pensions (3)
410. Compound Interest and Annuities — Certain (3)
411. Life Contingencies I (3)
412. Life Contingencies II (3)
496. Independent Studies (1-18)
497. Special Topics (1-9)

500. Management of the Insurance Enterprise (3) Management planning associated with risk bearing; pricing, reserving, reinsurance, and regulation; Lloyds and other significant world insurance markets; insurance intermediaries.

504. Problems in Insurance (3) Planned individual projects involving library, laboratory, or field work.

510. Risk Management (3) Analysis of managerial problems and responsibilities of risk analysis, removal or reduction, and allocation of corporate resources to provide indemnity.

596. Individual Studies (1-9)

INTERNATIONAL BUSINESS (I B)

421. (ACCTG 421) International Accounting (3)
496. Independent Studies (1-18)
497. Special Topics (1-9)

500. International Business Management (3) Concepts and institutions affecting the international conduct of business; interface between nations and international firms; alternative policies businesses employ internationally.

501. Comparative Business Systems (3) Conceptual approach analyzing and predicting influences of social, political, and economic norms and values upon diverse societies' managerial decision making.

502. International Business Macro Analysis (3) International economic, trade, political, and monetary tools are applied to national policy issues and international business operations. Prerequisite: I B 500.

503. International Business Policy (3) Analysis of the internal operations of multinational firms; design of optimal strategies of operation under varying environmental conditions. Prerequisite: I B 500.

504. Seminar in International Business (3-6) Seminar in techniques applied to selected topics; market structures; capital budgeting, investment; comparisons of foreign norms and values; multinational organization characteristics.

505. (FIN 505) Multinational Managerial Finance (3) Analysis of the international aspects of managerial finance. Emphasis on the environmental and institutional factors influencing capital acquisition and allocation. Prerequisite: FIN 531.

590. Colloquium (1-3)

596. Individual Studies (1-9)

597. Special Topics (1-9)

MANAGEMENT (MGMT)

401. Contemporary Issues in Management (3)
423. Organization Change and Development (3)
424. Interpersonal Relationships in Organizations (3)
441. Management of Personnel Systems (3)
471. Business Policy Formulation and Control (3)
496. Independent Studies (1-18)
497. Special Topics (1-9)

501. Behavioral Science in Business (3) Application of behavioral science concepts and analytical methods to problems in business organizations. Analysis of administrative behavior and decision making.

523. Organizational Change: Theory and Practice (3) Analysis of research, theory, and practice in dynamics of organizational change. Research literature reviewed for evaluation of concepts and methods.

524. Interpersonal Relations in Organizations (3) Development of skills and sensitivity for dealing with interpersonal relationships in complex organizations. Prerequisite: MGMT 501.

525. Management of Socio-Technical Systems (3) Theories and methods for diagnosing problems of productivity and quality of working life in organizations; planning, implementing, and evaluating solutions.

528. Seminar in Organizational Behavior (3) Current theoretical and research issues applicable to the study of individual and group behavior within organizational settings.

532. Complex Organizations: Structure and Design (3) The design and management of complex organizations from a managerial perspective.

538. Seminar in Organization Theory (3) Current theoretical and research issues applicable to the study of design and management of complex organizations.

541. Personnel Management (3) Theory and practice of personnel management and analysis of personnel problems of relevance to all types of managers.

548. Seminar in Personnel (3) Current theoretical and research issues applicable to the study of the design, implementation, and evaluation of personnel practices and programs.

571. Administrative Integration (3) An analysis of coordination of the functional areas of business in relation to overall company objectives.

575. Future Studies and Managerial Planning (3) Theory and research on the "future" dimensions of decision making and planning, particularly under conditions of rapid change.

576. Planning Models and Techniques (3) Survey of models, concepts, and techniques appropriate to managerial long-range planning in complex organizations.

578. Seminar in Corporate Strategy (3) Current theoretical and research issues applicable to the study of corporate strategy formulation and implementation.

590. Colloquium (1-3)

596. Individual Studies (1-9)

597. Special Topics (1-9)

MANAGEMENT INFORMATION SYSTEMS (M I S)

432. Accounting Information Systems (4)
433. Computer Audit and Control (4)
437. Introduction to Systems Analysis and Design (4)
438. Decision Support Systems (4)
439. Database Management Systems (4)
496. Independent Studies (1-18)
497. Special Topics (1-9)

531. Management Information Systems (1-3) Information system theories and methods applied to administrative structures and management decisions in organizations.

537. Management Information Systems Design (3) Cost, value, and technical considerations in analysis and design of information systems whose purposes are to aid decision making in organizations.

538. Information Systems for Planning and Control (3) Analysis of information requirements for planning, decision making, and performance measurement in organizations.

539. Seminar in Management Information Systems (3) Special topics selected from contemporary issues in management information systems.

590. M I S Colloquium (1-3) This seminar will deal with current research areas dealing with the development and management of management information systems within organizations. Prerequisite: M I S 531.

596. Individual Studies (1-9)

597. Special Topics (1-9)

MARKETING (MKTG)

422. Advertising and Sales Promotion Management (3)
424. Marketing Research Projects (3)
426. Industrial Marketing (3)
428. Sales Management (3)
450. Marketing Management Policies and Programs (3)
490. Advanced Buyer Behavior (3)
493. Quantitative Analysis for Marketing Management (3)
496. Independent Studies (1-18)
497. Special Topics (1-9)

500. Marketing Management (3) Development of a marketing management focus, including market analysis, competition analysis, and decisions in pricing, product, promotion, and distribution channels.

510. Planning Marketing Strategy and Programs (3) Development of marketing strategy consistent with corporate plans, including integrated marketing mix programs based on environmental, customer, and competitive analysis. Prerequisite: MKTG 500.

511. Quantitative Analysis for Marketing Decisions (3) Application of quantitative and analytical tools for marketing decisions in forecasting, new product development, advertising, promotions, pricing, and personal selling. Prerequisite: MKTG 500.

512. Consumer and Market Behavior (3) Application of buyer behavior concepts from the behavioral sciences, including utility, culture, life cycle, personality, attitudes, learning, decision making. Prerequisite: MKTG 500.

513. Market Research (3) User-oriented analysis of marketing research process, including problem definition, design, data collection, data analysis, interpretation, and presentation. Prerequisite: MKTG 500.

514. Management of Marketing Communications (3) Management of advertising, sales promotion, and personal selling programs. Topics: segmentation; copy, media, budget decisions; sales territory; and management issues. Prerequisite: MKTG 500.

515. Business Marketing (3) Study of marketing of goods and services to business, institutions, and government. Focus on organizational buying, market planning and analysis, and development of marketing mix. Prerequisite: MKTG 500.

516. Product Development and Management (3) Marketing and product strategies for new and old products are covered in this course. Prerequisite: MKTG 500.

551. Theoretical Perspectives on Buyer Behavior (3) Review of marketing and social sciences research related to understanding consumer and market behavior.

552. Marketing Theory (3) Theory building in marketing; the intricate relation of theory and research.

553. Development of Marketing Thought (1) Analysis of major contributions to the development of marketing thought.

554. Research Methods in Marketing (3) Philosophical, methodological, and measurement issues involved in designing, conducting, analyzing, and interpreting research in marketing.

555. Marketing Models (3) Topics in the model building approach to marketing decision making, focusing on current research issues.

596. Individual Studies (1-9)

597. Special Topics (1-9)

602. Supervised Experience in College Teaching (1-3 per semester, maximum of 6)

OPERATIONS MANAGEMENT (OPMGT)

415. Facilities Management (3)
416. Operations Planning and Control (3)
418. Materials Management (3)
496. Independent Studies (1-18)

510. Operations Management (3) Integration and application of decision making to operational and policy problems within the business firm.

515. Design of Operation Output Systems (3) Examination of research-based findings in operations management, with a focus on the design and reliability of production systems.

516. Operations Planning and Control (3) Examination of research-based findings in operations management. The focus is on the operation and control of production systems.

518. Management of Inventory Systems (3) Analysis of business organizations as integrated inventory systems. Inventory theory and model building as tools for management decision making. Prerequisite: OPMGT 510 or Q B A 561 or I E 509.

590. Colloquium (1-3)

596. Individual Studies (1-9)

597. Special Topics (1-9)

602. Supervised Experience in College Teaching (1-3 per semester, maximum of 6)

QUANTITATIVE BUSINESS ANALYSIS (Q B A)

403. Statistical Methods for Business Decisions (3)
404. Sampling in Business Operations and Research (3)
427. Management Decision Theory (3)
432. Simulation of Management Systems (3)
451. Linear Programming (3)
452. Nonlinear Programming (3)
461. Probabilistic Models in Business (3)
465. Managerial Forecasting (3)
490. Advanced Business Statistics (3)
496. Independent Studies (1-18)
497. Special Topics (1-9)

500. Seminar in Business Statistics (3-6)

501. Advanced Business Statistics (3)

510. Statistical Analysis for Managerial Decision Making (3) Use of statistical methods for managerial decision making, with emphasis on problem formulation, data analysis and interpretation, and business applications. Prerequisites: 3 credits each in undergraduate accounting, economics, and statistics.

511. Quantitative Analysis for Business Decisions (3) Construction and use of quantitative methods in business decision making. Prerequisite: common requirements of M.B.A. program.

527. Analysis for Decision Making Under Uncertainty (3) Topics in decision making under uncertainty, including decision theory, Bayesian statistics; payoff function, including utility theory and multi-attribute measures.

532. Management Systems Simulation (3) Application of computer simulation to the analysis and design of management decision systems. Design of simulation experiments in business research. Prerequisite: 3 credits of computer programming.

533. Regression Analysis for Business Decisions (3) The development and use of regression models in the analysis of business decisions.

537. Multivariate Analysis for Business Decisions (3) The development and use of multivariate statistical models in the analysis of business decisions.

540. Mathematical Programming (3) Nonlinear programming and geometric programming, with emphasis on both theory and applications. Prerequisite: Q B A 452.

550. Seminar in Mathematical Programming (3-6) Intensive treatment of theory and computational algorithms of mathematical programming; emphasis on operational application to complex management and business problems. Prerequisite: I E 510.

561. Stochastic Models for Management Decisions (3) Introduction to stochastic processes in business organizations. Application of stochastic models to the conceptualization, analysis, and solution of management problems. Prerequisite: MATH (STAT) 416.

565. Managerial Forecasting (3) The use of time-series models, including exponential smoothing and Box-Jenkins (ARIMA) techniques for business and economic forecasting.

567. Nonparametric Statistics for Business Analysis (3) The use of nonparametric statistical techniques in the analysis of business decisions.

570. Management Science: Implementation and Control (3) Development and application of management science models. Model formulation and specification, sensitivity analysis, problems encountered in implementation and control.

590. Colloquium (1-3)

596. Individual Studies (1-9)

597. Special Topics (1-9)

602. Supervised Experience in College Teaching (1-3 per semester, maximum of 6)

REAL ESTATE (R EST)

410. The Valuation of Real Property (3)
450. Seminar in Real Estate (3)
496. Independent Studies (1-18)
497. Special Topics (1-9)

510. Real Estate Financial Analysis (3) Real estate finance and investment analysis. Topics include housing, demand and supply of credit, and real estate investment strategies.

515. Issues in Real Estate Analysis (3) Topics deal with current issues facing real estate owners, investors, lenders, developers, governments, and society.

596. Individual Studies (1-9)

597. Special Topics (1-9)

602. Supervised Experience in College Teaching (1-3 per semester, maximum of 6)

BUSINESS ADMINISTRATION (B ADM)

JOHN M. MAGENAU, *Director of the M.B.A. Program*
Penn State Erie, The Behrend College
Station Road
Erie, PA 16563

Degree Conferred: M.B.A.

Associate Members of the Graduate Faculty
Stuart J. Allen, Ph.D. (Minnesota) *Associate Professor of Management*
John L. Fizel, Ph.D. (Michigan State) *Assistant Professor of Economics*
James A. Kurre, Ph.D. (Wayne State) *Assistant Professor of Economics*
John M. Magenau, Ph.D. (SUNY-Buffalo) *Associate Professor of Management*
Marc S. Mentzer, Ph.D. (Indiana) *Assistant Professor of Management*
Robert K. Rayner, Ph.D. (Michigan) *Assistant Professor of Management Science*
Lee D. Sailer, Ph.D. (California-Irvine) *Assistant Professor of Management Science*
Barry R. Weller, Ph.D. (Penn State) *Associate Professor of Economics*
Chester Wolford, Ph.D. (Penn State) *Associate Professor of English*

The Penn State-Behrend M.B.A. program recognizes that sound judgment and effective communication are best developed through experience in solving problems. Managers must be able to interpret information, analyze data both quantitatively and qualitatively, and select the appropriate tools for the task at hand. To develop these skills, each M.B.A. course confronts students with a series of problems containing incomplete information and offering multiple solutions.

Admission Requirements
Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin*.

Applicants are required to take the Graduate Management Admissions Test (GMAT) administered by the Educational Testing Service (ETS) four times a year. All arrangements should be made directly with the Educational Testing Service, Box 966, Princeton, NJ 08541; telephone (609) 771-7330.

Admission decisions are based on the following: undergraduate grade-point average; work experience; the degree of correspondence between the applicant's objectives and those of the program; three letters of reference; and GMAT score. Entering graduate students for whom English is not the first language are required to have a score of at least 550 on the TOEFL (Test of English as a Foreign Language) examination. Admission is open during the fall and spring semesters, as well as during the summer session.

Master's Degree Requirements

The Master of Business Administration degree program consists of a core of twelve required courses (36 credits) and four elective courses (12 credits). The core courses cover accounting, business environment, communications, economics, finance, information systems, management, marketing, organizations, planning and policy, production and operations management, and statistics. Where appropriate, each core course also contains an international business component.

These core courses develop the qualitative and quantitative tools that managers need for problem solving. Information systems foster skills in the organization and use of data. The focus of the M.B.A. program is the appropriate use of these tools and skills in solving unstructured problems that involve several functional areas.

Elective courses allow students to pursue a particular area in depth and to gain an appreciation of more complex issues facing managers. Program participants may select from courses in human resources, information systems, international business, marketing, operations management, and quantitative analysis.

Student Aid

Graduate assistantships available to students in this program and other forms of student aid are described in the STUDENT AID section of the *Graduate Bulletin*.

ACCOUNTING (ACNTG)

501. Financial and Managerial Accounting (3) Comprehensive study of financial accounting: financial information for internal management, planning and special decisions, cost determination, performance evaluation, and control. Prerequisite: ACCTG 101 or 104.

521. Advanced Accounting Theory (3) Intensive study of accounting principles at an advanced level for students who have had a thorough accounting program. Prerequisite: ACNTG 501.

531. Advanced Income Tax (3) Tax regulations applicable to partnerships, corporations, estates, and trusts, with emphasis on tax determination and planning. Prerequisite: ACNTG 210.

596. Individual Studies (1-9)

597. Special Topics (1-9)

COMMUNICATIONS (COMMU)

501. Business Communications (3) A survey of, and practice in, methods and procedures of good business communications. Prerequisite: knowledge of basic English grammar, syntax, and usage required.

596. Individual Studies (1-9)

597. Special Topics (1-9)

ECONOMICS (ECNS)

501. Managerial Economics (3) Application of economic theory to managerial decision making. Prerequisite: ECON 002 or 004.

502. Macroeconomic Theory and Policy (3) Analysis of factors influencing the level of aggregate economic activity. Prerequisites: ECNS 501, QANLY 501.

511. The Business Cycle and Stabilization Policy (3) A survey of contemporary business cycle analysis, including theories of the cycle, cycle measurement, forecasting, and stabilization policy. Prerequisites: ECNS 501, QANLY 501.

521. Money and Banking (3) Principles of money, banking, and credit. Prerequisite: ECNS 501.

541. Business Forecasting (3) A survey of contemporary business forecasting techniques, including smoothing, decomposition, regression, and time series analysis. Prerequisites: ECNS 501, QANLY 501.

596. Individual Studies (1-9)

597. Special Topics (1-9)

FINANCE (FNC)

501. Financial Management (3) Financial management of the firm, with special emphasis on financial planning, capital budgeting, and cost of capital concepts.

521. Financial Institutions (3) Characteristics of financial institutions: services, assets management and growth; investment demand, government policies, consumer behavior, and savings intermediaries. Prerequisite: FNC 501.

531. Investment Theory (3) Advanced literature pertaining to investments; special reference to the theory of random walks, stock valuation models, and portfolio management. Prerequisite: FNC 521.

596. Individual Studies (1-9)

597. Special Topics (1-9)

INTERNATIONAL BUSINESS (INT B)

511. International Business Administration (3) Government and business relationship patterns worldwide; economic and political philosophies, government in economic planning, economic development, control of private business. Prerequisite: MANGT 531.

512. International Business Theory and Policy (3) Examination of international business theories, international economic theories, international strategy and policy concerns, and their effect on the firm. Prerequisite: INT B 511.

596. Individual Studies (1-9)

597. Special Topics (1-9)

MANAGEMENT (MANGT)

501. Principles of Management (3) An overview of the basic functions of management.

503. Managerial Perspectives (3) Seminar directed by experienced executives on contemporary topics and issues of concern to organizations. Prerequisites: ECNS 501, MANGT 531.

531. Organizations (3) An examination of organizational theories and processes of organizational behavior.

543. Legal, Political, and Social Environment of Business (3) The interaction of business with society and with the legal and political environments.

545. Entrepreneurial Ventures (3) The contribution of the entrepreneur to the enterprise system, supporting public policies and personal requirements for entrepreneurial success. Prerequisites: ACNTG 501, FNC 501, MANGT 543.

551. Human Resources Management (3) An overview of areas of human resources management. Prerequisites: MANGT 501, QANLY 501.

553. Labor Relations (3) Labor relations in the modern business organization.

571. Strategic Planning and Business Policy (3) Formulation of objectives and the implementation of programs to promote long-range success of the organization in a changing environment. Prerequisite: completion of all other core courses.

572. Strategic Decision-Making Models and Systems (3) Structures, methodologies, and systems to support decision making in situations characterized by lack of data, uncertain environments, and policy constraints. Prerequisite: MANGT 571.

596. Individual Studies (1-9)

597. Special Topics (1-9)

MANAGEMENT INFORMATION SYSTEMS (MISBD)

501. Information Systems in Organizations (3) Understanding and analyzing information in organizations; fundamental concepts of systems and information.

521. Systems Analysis and Design (3) Introduces tools of information analysis and requirements specification in organizations: development strategies, management, behavior, problem finding, requirements determination, and specification. Prerequisite: MISBD 501.

531. Database Management Systems (3) Introduces concepts of file structures, access techniques, data management, models and implementations, database administration, data query, update, and report generation. Prerequisite: MISBD 501.

596. Individual Studies (1-9)

597. Special Topics (1-9)

MARKETING (MRKTG)

501. Marketing (3) Introduces students to marketing's role in society, within the firm, in decision making, information gathering, and in developing marketing mixes.

531. Consumer Behavior (3) An examination of marketing, psychological, and sociological factors affecting consumer decision making. Prerequisite: MRKTG 501.

541. Marketing Research (3) Examination of marketing research today, including research and marketing decisions, sampling and measurement, and collection and analysis of data. Prerequisites: MRKTG 501, QANLY 501.

551. Marketing Management: Strategies and Cases (3) Exposes students to a wide variety of authentic and realistic marketing problems and situations; case methods used. Prerequisite: MRKTG 501, 531.

596. Individual Studies (1-9)

597. Special Topics (1-9)

OPERATIONS MANAGEMENT (OPMAN)

501. Operations Management (3) Quantitative models to aid in the decision-making process connected with operating and controlling the production of goods and services. Prerequisite: QANLY 501.

596. Individual Studies (1-9)

597. Special Topics (1-9)

QUANTITATIVE ANALYSIS (QANLY)

501. Statistics for Modern Business Decision Making (3) A survey of statistical techniques to aid in the decision-making process. Prerequisite: STAT 200.

502. Advanced Decision Theory (3) Topics in decision theory and game theory with business applications. Prerequisite: QANLY 501.

510. Applied Multivariate Statistics I (3) An introductory course in multivariate analysis covering fundamental concepts, inferences, and comparison of several population means. Prerequisite: Q B A 102.

511. Applied Multivariate Statistics II (3) A continuation of multivariate analysis which explores linear regression, the most important factor analysis issues, and the classification problem. Prerequisite: QANLY 510.

515. Methods of Operations Research: Deterministic Models (3) A survey of deterministic models and their applications to business-related problems. Prerequisite: differential calculus.

516. Methods of Operations Research: Probabilistic Models (3) A survey of probabilistic models and their application to business-related problems. Prerequisite: QANLY 501.

521. Business Logistics (3) The role of logistics and physical distribution. Prerequisites: MISBD 501, QANLY 515.

541. Management Systems Simulation (3) Simulation techniques in business; introduction to simulation software. Prerequisite: QANLY 501.

596. Individual Studies (1-9)

597. Special Topics (1-9)

BUSINESS ADMINISTRATION (BADMN)

JACOB DE ROOY, *Director of the M.B.A. Program*
Penn State Harrisburg, The Capital College
E-355 Olmsted Building
Middletown, PA 17057
717-948-6140

Degree Conferred: M.B.A.

Senior Members of the Graduate Faculty
Melvin Blumberg, Ph.D. (Penn State) *Professor of Management*
Robert J. Brown, Ph.D. (NYU) *Associate Professor of Finance*
Terence A. Brown, D.B.A. (Maryland) *Associate Professor of Transportation and Marketing*
Jacob De Rooy, Ph.D. (Rutgers) *Associate Professor of Managerial Economics and Statistics*
Carolyn R. Dexter, Ph.D. (Columbia) *Associate Professor of Management and Marketing*
Erdener Kaynak, Ph.D. (Cranfield) *Professor of Marketing*

Associate Members of the Graduate Faculty
Refik Culpan, Ph.D. (NYU) *Assistant Professor of Management*
Mehdi Khosrowpour, D.B.A. (Nova) *Assistant Professor of Computer Applications*
Mulkund Kulkarni, Ph.D. (Kentucky) *Assistant Professor of Finance*
Horng-Ching Kuo, Ph.D. (Mississippi) *Assistant Professor of Accountancy*
Malcolm H. Liggett, Ph.D. (Cornell) *Associate Professor of Economics and Labor Relations*
Vedula N. Murti, Ph.D. (Pennsylvania) *Assistant Professor of Economics and Statistics*
Kurt H. Parkum, Ph.D. (Wisconsin) *Assistant Professor of Health Care and Organizational Behavior*
Vijaya Saradhi P. Sishtla, Ph.D. (Osmania) *Professor of Accountancy*
David G. Watkin, D.Ed. (Penn State) *Assistant Professor of Management*
Ugur Yucelt, Ph.D. (New School) *Associate Professor of Marketing*

The Master of Business Administration, which is offered at Penn State Harrisburg, The Capital College, is a professionally oriented degree program intended for persons seeking or holding management positions in business firms or in other technical and service organizations. The goals of the program are to develop competence in decision making; the ability to integrate and interrelate the various functions of the firm; an understanding of the environment in which the firm operates; skill in interpersonal and group relations; a sense of responsibility to society; and a commitment to ethical action within and outside the firm. The degree may be earned through full- or part-time study in the evening.

Admission Requirements
Scores from the Graduate Management Admission Test (GMAT) are required for admission. Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin*.

An applicant must hold a baccalaureate degree in any field from an accredited, college-level institution. Admission decisions are based primarily on an applicant's junior-senior cumulative grade-point average and GMAT scores. Results of any postbaccalaureate course work, professional experience, and the applicant's statements provided in the application also are considered. Letters of

recommendation are optional. The best-qualified applicants will be accepted up to the number of spaces available for new students.

In addition to GMAT scores, applicants whose native language is not English must provide scores from the Test of English as a Foreign Language (TOEFL). To reflect an applicant's current aptitude for business studies accurately, both GMAT and TOEFL tests should have been completed within the past five years.

The GMAT and TOEFL are administered by the Educational Testing Service in October, January, March, and June. For applications, dates, locations, and other information about the tests, applicants may write to the Educational Testing Service, Box 966, Princeton, NJ 08541. All arrangements for taking these tests are made directly with the Educational Testing Service.

Application Deadline: Candidates may enter the program at the beginning of the fall or spring semester or the summer session. To allow time for processing the applications, all required information must be received by July 18 for the fall semester, November 18 for the spring semester, and April 18 for the summer session. Because of the need to obtain various clearances, international students should submit all required information at least two months earlier than the deadline. Applications can be requested from the Penn State Harrisburg Admissions Office, 717-948-6200.

Transfer Credits: Academic credit up to a maximum of 10 credits of high-quality work done at other accredited institutions may be applied toward requirements for the M.B.A. degree. Credits used to complete a previous degree, however, may not be applied. Transferred academic work must have been completed within six years prior to admission to the program, must be of at least B quality, and must appear on a graduate transcript. Pass-fail grades are not transferable to an advanced degree program unless the "Pass" can be substantiated by the institution where it was earned as having at least B quality.

Waivers: The M.B.A. program is clustered into three groups of course work: (1) Common Body of Knowledge courses, (2) Breadth courses, and (3) Electives. Common Body of Knowledge (CBK) courses are further clustered into three sequences. Courses in sequence A may be waived on the basis of 6 credits of equivalent undergraduate, or 3 credits of equivalent graduate-level, course work completed with a grade of B or higher at an accredited, college-level institution within six years prior to admission. CBK courses in sequence A may also be waived on the basis of a proficiency examination where the M.B.A. program director believes that a student's background and experience provide a reasonable basis for passing the examination. Three graduate credits of additional elective course work must be taken as a substitute for any course that is waived on the basis of an examination or undergraduate course work.

Notification of waivers granted by the program will be given during the orientation period for new students. Students intending to waive a CBK course by examination should arrange to take an examination shortly after admission to the program. There is a $30 per credit fee to sit for the examination whether or not it is passed. A Petition for Waiver form can be obtained from the M.B.A. program office.

Mathematics Requirement: Students are required to demonstrate competence in mathematics through college-level calculus prior to enrolling for their M.B.A. course work. This may be demonstrated by (1) satisfactory completion of a college-level calculus course, such as QUANT 310 offered at Penn State Harrisburg, with a grade of B or better within six years prior to admission to the M.B.A. program or (2) successful completion of a mathematics proficiency examination approved by the M.B.A. program.

Proficiency in Writing and in the Use of Computers: Two skills required in the program are the ability to present well-written reports and the ability to make effective use of computer facilities and applications software such as word processing, spread sheet analysis, and statistical packages. Candidates who are weak in these skills should improve their level of proficiency through course work or self-study prior to applying for the M.B.A. program.

Master's Degree Requirements

The M.B.A. degree requires 54 credits of course work. The number of credits may be reduced, however, for students having applicable transfer credits. A minimum of 30 credits must be taken at Penn State Harrisburg. These credits must be distributed over the three groups of courses described below.

1. *Common Body of Knowledge Courses* (33 credits) + : Courses in sequence A must be completed before courses in sequence B may be taken. With the exception of BUS 588, courses in sequences B and C may be taken concurrently. BUS 588 should be among the last 6 credits taken in the M.B.A. program. All other Common Body of Knowledge courses must be completed before breadth or elective courses may be taken.

Sequence A (15 credits) is designed to provide knowledge of quantitative managerial tools, economic theory, and the behavioral aspects of organizations. They provide a foundation for later courses and must be completed first. Required courses are BUS 501, 502, ECNMS 501, MNGMT 510, and P ACC 501.

Sequence B (9 credits) surveys the functional areas of business and further develops and applies the methods learned in sequence A to decision making in finance, production, and marketing. With the exception of BUS 588, sequence B courses may be taken concurrently with courses in sequence C. Required courses are MRKT 520, FINAN 521, and MNGMT 522.

Sequence C (9 credits) examines the information, international, legal, and administrative processes that provide both opportunities and constraints to general management in relating organizations to their external environments. Required courses are BUS 584, 588, and INFSY 540.

2. *Breadth Courses* (15 credits): These courses provide advanced work beyond that required by Common Body of Knowledge courses and are aimed at developing a general competence for overall management. Preparation of a professional paper is required. Required courses are BUS 550*; BUS 551* or 554@; ECNMS 510; FINAN 530; MRKT 570; and P ACC 540.

3. *Elective Courses* (6 credits): These courses allow students to select additional courses of interest. Electives may be selected from the following: BUS 520, 552, 556, 560, 589, 597; FINAN 531; I B 501; MNGMT 505, 511, 512, 515, MRKT 571, 572.

Student Aid

Graduate assistantships available to students in this program and other forms of student aid are described in the STUDENT AID section of the *Graduate Bulletin*.

COURSES‡

BUS 491. Managerial Statistics (3)
BUS 492. Management Science (3)
FINAN 492. Business Finance (3)
MNGMT 491. Management Information Systems (3)
P ACC 491. Accelerated Elementary Accounting (3)

BUSINESS (BUS)

501. Statistical Analysis for Business Decisions (3) Application of statistical techniques to the formulation, analysis, interpretation, and solution of business problems. Prerequisite: admission to M.B.A. program.

502. Quantitative Methods (3) Development and business applications of management science models. Prerequisite: BUS 501, admission to graduate degree candidacy.

520. Administrative Models (3) Formulation and solution of decision models for administrative problems. Analysis of decision making under certainty, risk, and uncertainty. Prerequisite: BUS 502.

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*BUS 550 and 551 must be taken concurrently. Students must register for BUS 550 and 551, or for BUS 554. These courses must be completed successfully before a student will be permitted to register for the last 6 credits in the M.B.A. program.

@BUS 554 may be taken only after consultation with the adviser and with the permission of the M.B.A. program.

+ Common Body of Knowledge courses are reserved exclusively for graduate degree candidates.

‡Course descriptions not given below can be found under the designated field of study

550. Business Research Methods (1) Selection of a research topic, construction of a bibliography, literature survey and data collection, and preparation of a research proposal. Prerequisite: This course must be completed successfully (grade of A, B, or C) before registering for the last 6 credits of the M.B.A. program. Concurrent: BUS 551.

551. Master's Paper (2) Completion of a professional paper in the student's major field of interest under supervision of a faculty member. Prerequisite: This course must be completed successfully (grade of A, B, or C) before registering for the last 6 credits of the M.B.A. program. Concurrent: BUS 550.

552. Advanced Managerial Statistics (3) Application of statistical methods for analyzing the relationships between two or more variables, such as multiple regression. Prerequisite: BUS 501.

554. Master's Project (3) Development of an original master's project in the student's professional field of interest and preparation of a paper. Prerequisite: This course must be completed successfully (grade of A, B, or C) before registering for the last 6 credits of the M.B.A. program.

556. Economic and Business Forecasting (3) Application and evaluation of methods for forecasting regional economic change and business activity. Prerequisites: BUS 501, ECNMS 501.

560. Sampling Theory and Practice (3) Study of scientific method of obtaining representative samples, collection of information, techniques of estimation. Prerequisite: BUS 491.

584. Business in a Global Society (3) Business sector and society relations; international and cultural issues; corporate values and ethics; relationship to stakeholders; social, political, legal environments. Prerequisites: ECNMS 310, 311.

*588. Business Policy Formulation (3) Analysis of administrative problems from a total organization viewpoint. Case studies of actual organizations are used for analysis. Prerequisite: all course work or permission of instructor.

589. Small Business Management Practicum (1-3) Advanced study and practice in small business management through field assignments with cooperating firms to analyze and solve managerial problems.

590. Colloquium (1-3)

596. Individual Studies (1-9)

597. Special Topics (1-9)

ECONOMICS (ECNMS)

510. Managerial Economics (3) Development of economic models for analyzing demand, cost behavior, production relationships, pricing policies, and capital budgeting in the firm. Prerequisite: ECNMS 501.

FINANCE (FINAN)

521. Financial Management (3) Consideration of modern financial management methods emphasizing the development of conceptual and analytical techniques for decision making and policy formulation. Prerequisites: BUS 501, ECNMS 501, P ACC 501, admission to M.B.A. program.

530. Advanced Financial Management (3) The financial aspects of management, including subjects of general interest to managers. Prerequisites: FINAN 521.

531. Managing Financial Operations (3) A course for financial managers; working capital management; financial planning, financial controls, reporting, financial strategies; theory and practice. Prerequisites: BUS 502, FINAN 521.

596. Individual Studies (1-9)

597. Special Topics (1-9)

*Course to be taken during student's last semester — recommended tool courses must be completed.

INTERNATIONAL BUSINESS (I B)

501. Comparative Business Systems (3) Conceptual approach analyzing and predicting influences of social, political, and economic norms and values upon diverse societies' managerial decision making.

MANAGEMENT (MNGMT)

505. Personnel Management (3) Problems in effectively selecting, utilizing, and developing human resources from the viewpoint of the total organization — both private and public.

510. (P ADM 510) Organizational Behavior (3) Examination of concepts of human behavior in formal organizations, systems analysis, conceptual models, and decision processes.

511. (P ADM 511) Organizational Change and Development (3) Theory of organizational change and development; case analysis of applications in actual situations. Prerequisite: MNGMT 500, 510.

512. Administrative Theory (3) Advanced analysis of selected areas of administrative theory and research, with special emphasis on application to current organizational problems. Prerequisite: MNGMT 510.

515. (P ADM 515) Labor-Management Relations (3) Labor relations issues; collective bargaining agreement, negotiations, and administration; legal framework of collective bargaining; labor relations in larger social context.

522. Operations Management (3) Integration and application of decision making to operational and policy problems within the business firm. Prerequisite: BUS 502.

596. Individual Studies (1-9)

597. Special Topics (1-9)

MARKETING (MRKT)

520. Marketing Management (3) Consideration of modern marketing concepts, application, and managerial issues. Prerequisites: BUS 501, ECNMS 501, MNGMT 510, admission to M.B.A. program.

570. Marketing Management (3) Analysis of management's marketing problems, including marketing analyses, pricing, channels of distribution, promotion, competition, product strategies, and marketing research. Prerequisite: MRKT 520.

571. Consumer Behavior (3) Factors influencing buyer behavior; contributions of the behavioral sciences to the study of selected phenomena. Prerequisite: MRKT 520.

572. Research and Marketing Management (3) Management information needs, evaluation of search proposals and findings, methods of data collection and analysis, integration of research and decisions. Prerequisite: MRKT 520.

596. Individual Studies (1-9)

597. Special Topics (1-9)

PROFESSIONAL ACCOUNTANCY (P ACC)

501. Managerial and Financial Accounting (3) Theory and techniques of financial and managerial accounting; preparation of financial statements and analysis of internal accounting data. Prerequisite: admission to M.B.A. program.

540. Managerial Accounting (3) Fundamental financial and managerial accounting concepts and issues from the viewpoint of the report user. Prerequisite: P ACC 501.

596. Individual Studies (1-9)

597. Special Topics (1-9)

CELL AND MOLECULAR BIOLOGY (CMBIO)

STEVEN R. GOODMAN, *Director of the Cell and Molecular Biology Center*
The Milton S. Hershey Medical Center
Hershey, PA 17033
717-531-6608

Degrees Conferred: Ph.D., M.S.

Senior Members of the Graduate Faculty
V. P. Bhavanandan, Ph.D. (Edinburgh) *Professor of Biological Chemistry*
Eugene A. Davidson, Ph.D. (Columbia) *Professor and Chair of Biological Chemistry*
Steven R. Goodman, Ph.D. (St. Louis) *Professor of Physiology and Head of the Multidisciplinary Laboratories*
Charles W. Hill, Ph.D. (Wisconsin) *Professor of Biological Chemistry*
Anita K. Hopper, Ph.D. (Illinois) *Professor of Biological Chemistry*
James E. Hopper, Ph.D. (Wisconsin) *Professor of Biological Chemistry*
Richard W. Hyman, Ph.D. (California Tech.) *Professor of Microbiology*
Harriet C. Isom, Ph.D. (Illinois) *Professor of Microbiology*
Samson T. Jacob, Ph.D. (Agra-India) *Professor of Pharmacology*
Leonard S. Jefferson, Ph.D. (Vanderbilt) *Professor of Physiology*
John W. Kreider, M.D., Ph.D. (Pennsylvania) *Professor of Pathology and Microbiology*
Kathryn F. LaNoue, Ph.D. (Yale) *Professor of Physiology*
Bryce L. Munger, M.D. (Washington-St. Louis) *Professor and Chair of Anatomy*
Anthony E. Pegg, Ph.D. (Cambridge) *Evan Pugh Professor of Physiology*
Donald Eugene Rannels, Ph.D. (Penn State) *Professor of Physiology*
George Rose, Ph.D. (Oregon State) *Professor of Biological Chemistry*
Cara-Lynne Schengrund, Ph.D. (Seton Hall) *Professor of Biological Chemistry*
Ross Shiman, Ph.D. (California) *Professor of Biological Chemistry*
David J. Spector, Ph.D. (Pennsylvania) *Associate Professor of Microbiology*
Mary J. Tevethia, Ph.D. (Michigan State) *Professor of Microbiology*
Satvir S. Tevethia, Ph.D. (Michigan State) *Professor of Microbiology*
Carol F. Whitfield, Ph.D. (George Washington) *Associate Professor of Physiology*
Jang-Yen Wu, Ph.D. (California) *Professor of Physiology*
Ian S. Zagon, Ph.D. (Colorado) *Professor of Anatomy*

Associate Members of the Graduate Faculty
Melvin L. Billingsley, Ph.D. (George Washington) *Associate Professor of Pharmacology*
William Hendrickson, Ph.D. (Tufts) *Assistant Professor of Microbiology*
Ralph L. Keil, Ph.D. (Cornell) *Assistant Professor of Biological Chemistry*
Paul G. Szauter, Ph.D. (Washington) *Assistant Professor of Biological Chemistry*
Brian Wigdahl, Ph.D. (Medical College of Wisconsin) *Assistant Professor of Microbiology*

The Cell and Molecular Biology program is interdepartmental within the College of Medicine and is designed to enable students to obtain an integrated series of courses leading to Ph.D. and M.S. degrees. The program encompasses both the fundamentals of cell and molecular biology and advanced laboratory training in a specialized area. All courses are available at the College of Medicine.

The student's research begins at the end of the first year's course work. Faculty in this program are competent to prepare students in almost all subfields of cell and molecular biology, including membrane structure, receptors, and modulators; cytoskeletal structure and function; neuronal and glial cell culture, and the role of extracellular matrix in their interactions; organelle structure and function; cell division, differentiation, adhesion, communication, and movement; recombination, organization, and expression of genes, gene mapping and recombinant DNA, and regulation of gene expression. Modern well-equipped laboratories are available for graduate study from the molecular to tissue levels.

Admission Requirements
Scores from the Graduate Record Examination (GRE), or from a comparable substitute examination accepted by a graduate program and authorized by the dean of the Graduate School (e.g., MCAT exam), are required for admission. At the discretion of the graduate program, a student may be admitted provisionally for graduate study in the program without these scores. Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin*.

Admission to the program is based on prior course record and grades, GRE scores, letters of recommendation, and interviews. Virtually all students are admitted with the intent of obtaining a Ph.D. degree. The M.S. degree may be sought as a part of the doctoral program.

Doctoral Degree Requirements

The formal course requirements depend upon the individual student's career goals. Each student will be required to complete the following successfully: (1) A candidacy examination covering the general course material that will consist of a written portion to test factual knowledge and an oral portion to examine research potential. The examination will be given after completion of the spring semester of the first year. (2) A communications requirement to be completed after the candidacy examination. (3) A comprehensive examination consisting of a written research proposal and an oral defense of that proposal will be required after completion of the spring semester of the second year. (4) An original research project under the supervision of a Cell and Molecular Biology faculty adviser. (5) A thesis. (6) A final oral defense of the thesis. The program is designed for completion within four years, but this can vary depending on the individual progress of the student.

Student Aid

Graduate assistantships available in this program and other forms of student aid are described in the STUDENT AID section of the *Graduate Bulletin*. Graduate assistantships in the program are awarded by the Cell and Molecular Biology Program Committee. After the second year, Cell and Molecular Biology students are eligible for departmental teaching or research assistantships and other assistantships supported by grant funds of individual faculty members. The program encourages all Ph.D. candidates to apply for fellowships, scholarships, and stipend support from outside sources. For students obtaining outside fellowships, scholarships, and stipend support, supplementation to the level of the assistantships will be provided.

CELL AND MOLECULAR BIOLOGY (CMBIO)

503. (BCHEM 503, MICRO 503) Molecular Biology (3) Principles of molecular and microbial genetics; emphasis placed on experimental design toward problems in bacteria and lower eucaryotes. Prerequisite: BCHEM 502.

513. (BCHEM 513) Principles of Protein Structure (3) Review of thermodynamics; physical chemistry and architecture of globular proteins; predictive approaches; laboratory in computer modeling of three-dimensional structure.

518. (PHARM 518) Eukaryotic Gene Regulation (2) Emphasis will be on the regulation of gene expression in higher organisms. Prerequisites: BCHEM 502, 503, 505, MICRO 503.

520. (BCHEM 520) Genetic Analysis (3) Genetics of organisms most used in the analysis of problems in molecular biology: drosophila, yeast, and bacteria.

530. (PSIO 530) Metabolic and Endocrine Physiology (3) Regulation of carbohydrates, fatty acid, and protein metabolism; regulation of hormone secretion; effects of hormones on water and cell metabolism.

540. (PSIO 540) Cell Biology (3) Lectures in cell biology, including membrane, cytoskeleton, and organelle structure and function; cell division, differentiation, adhesion, communication, and movement. Prerequisite: BCHEM 502.

541. (PHARM 541) Cellular Communication (2) This course explores the cellular and molecular basis of signal generation and information transduction in cells. Prerequisites: BCHEM 505, CMBIO 540.

546. (ANAT 546) Concepts of Development (2) This course evaluates developmental processes at the cellular and molecular level, with an emphasis on the regulatory mechanisms involved. Prerequisite: CMBIO 540.

550. (ANAT 550) Quantitative Optics and Cytology (3) Study of the various types of light microscopy instruments and application of these tools to quantitative measurements in biological systems.

551. (BCHEM 551) Kinetics and Catalysis in Biochemical Systems (3) Information obtainable from steady-state and transient kinetic measurement on enzymes and cellular processes. Molecular basis for enzyme specificity and catalysis. Prerequisite: BCHEM 502.

560. (MICRO 560) Concepts in Immunology (3) Lectures in advanced immunology, including T and B cell function, receptors, gene rearrangements, and synthetic vaccines.

590. Colloquium (1-3)

596. Individual Studies (1-9)

597. Special Topics (1-9)

CERAMIC SCIENCE (CERSC)

KARL E. SPEAR, *In Charge of Graduate Programs in Ceramic Science*
201 Steidle Building
814-865-4992

Degrees Conferred: Ph.D., M.S.

Senior Members of the Graduate Faculty
Herbert A. McKinstry, Ph.D. (Penn State) *Associate Professor of Solid State Technology*
Gary L. Messing, Ph.D. (Florida) *Associate Professor of Ceramic Science and Engineering*
Robert E. Newnham, Ph.D. (Penn State, Cambridge) *Professor of Solid State Science*
Carlo G. Pantano, Ph.D. (Florida) *Associate Professor of Materials Science and Engineering*
Guy E. Rindone, Ph.D. (Penn State) *Professor Emeritus of Ceramic Science and Engineering*
Karl E. Spear II, Ph.D. (Kansas) *Professor of Ceramic Science*
Vladimir S. Stubican, Dr.Phil. (Zagreb), D.Sc. *Professor of Materials Science and Engineering*
Richard E. Tressler, Ph.D. (Penn State) *Professor of Materials Science and Engineering*
William O. Williamson, D.Sc. (London) *Professor Emeritus of Ceramic Science and Engineering*

Associate Members of the Graduate Faculty
James H. Adair, Ph.D. (Florida) *Assistant Professor of Ceramic Science and Engineering*
Paul W. Brown, Ph.D. (Wisconsin) *Associate Professor of Ceramic Science and Engineering*
David J. Green, Ph.D. (McMaster) *Associate Professor of Ceramic Science and Engineering*
John R. Hellman, Ph.D. (Penn State) *Assistant Professor of Ceramic Science and Engineering*
Wayne Huebner, Ph.D. (Missouri) *Assistant Professor of Ceramic Science and Engineering*
John J. Mecholsky, Jr., Ph.D. (Catholic) *Associate Professor of Ceramic Science and Engineering*

In addition to these faculty members, other Materials Science, Electrical Engineering, and Geoscience faculty members advise or co-advise Ceramic Science graduate students.

This program is one of the advanced degree options in the Department of Materials Science and Engineering. In view of the wide field covered by ceramic science, the graduate courses may be selected with special emphasis in ceramic processing, physical ceramics, chemical ceramics, or glass science.

Special facilities exist for research in the areas of electroceramics, ceramic processing, phase equilibria, solid-state synthesis, mechanical properties, ferrite and ferroelectric studies, glass science, surface characterization and properties, high-temperature reaction kinetics, and corrosion studies. Suitable preparation for graduate study in this program may be found in one of the material sciences, such as ceramics or metallurgy, in engineering fields such as chemical or mechanical engineering, in the basic physical sciences, or in the earth sciences.

Admission Requirements
Scores from the Graduate Record Examination (GRE) are required for admission. At the discretion of a graduate program, a student may be admitted provisionally for graduate study in the program without these scores. Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin*.

Students with a 2.80 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.80 grade-point average may be made for students with special backgrounds, abilities, and interests.

Degree Requirements
The communication and foreign language requirement may be satisfied by (1) examinations in two languages or (2) examination in one foreign language and either 6 credits of computer science or 6 credits of statistics, or 3 credits of computer science and 3 credits of statistics.

Student Aid

Graduate assistantships available to students in this program and other forms of student aid are described in the STUDENT AID section of the *Graduate Bulletin*.

CERAMIC SCIENCE AND ENGINEERING (CERSE)

400. Nonmetallic Crystal Chemistry (2-3) *Newnham*
404. Ceramic Seminar (1)
406. Processing of Ceramics (3)
407. Ceramic Processing Laboratory (1)
408. Thermal Properties of Ceramic Materials (2) *Spear*
409. Refractories and Thermal Properties (1)
410. Phase Relations in Ceramic Systems (3) *Spear*
411. Reactions in Ceramic Systems (3)
412. Glass and Mechanical Properties Laboratory (1)
414. Mechanical Properties of Ceramics (3)
415. Principles of Glass Technology (3) *Pantano*
420. Refractories (2) *Stubican*
430. Electrical, Optical, and Magnetic Properties (3)
431. Electrical, Optical, and Magnetic Properties (1)
496. Independent Studies (1-18)

CERAMIC SCIENCE (CERSC)

501. Surface Behavior of Ceramic Materials (2-4) Surface chemistry of ceramics. Rheology of ceramic powders, suspensions, and pastes. *Messing*

502. Mechanical Properties of Ceramics I (3) Theoretical considerations of the crystallographic and microstructural aspects of the elastic properties and fracture characteristics of ceramics. Prerequisite: CERSE 414 or E MCH 415.

504. Solid State Reactions in Ceramic Systems (2) Thermodynamic, kinetic, and structural study of reactions and of equilibrium in ceramic systems. Prerequisites: CHEM 451, 452. *Stubican*

506. Mechanical Properties of Ceramics II (2) Theoretical considerations of dislocation processes, diffusion phenomena, and microstructural effects on the deformation and creep of ceramic materials. Prerequisite: CERSE 502.

507. Thermal Properties of Ceramic Materials (2-3) Heat capacity, heat of fusion, thermal conductivity, and thermal expansion in relation to macroscopic measurements and basic atomic concepts applied to ceramic materials. *Tressler*

508. Dielectric and Magnetic Properties of Ceramic Materials (2-3) Preparation and properties of ceramic semiconductors, dielectrics, and magnetic materials. *Newnham*

509. Composite Materials (3) Manufacturing processes, atomic and molecular background, and topological relationships of macro- and microstructure to the physical properties of composites. *Tressler*

510. Seminar in Glass Technology (1-2 per semester) Current developments in glass technology and related fields. *Pantano*

511. The Constitution of Glass (2-3 per semester) Historical and current concepts of the atomic structure of glass; relationship of structure to chemical and physical properties. *Pantano*

590. Colloquium (1-3) Continuing seminars which consist of a series of individual lectures by faculty, students, or outside speakers.

596. Individual Studies (1-9)

597. Special Topics (1-9)

602. Supervised Experience in College Teaching (1-3 per semester, maximum of 6)

Note: *Courses in the use of X-ray diffraction, electron microscopy, and the electron microprobe in ceramic science studies are listed under MATERIALS SCIENCE — as are introductory courses in thermodynamics, kinetics, crystal chemistry, and crystal physics.*

CHEMICAL ENGINEERING (CH E)

J. LARRY DUDA, *Head of the Department*
160 Merrell R. Fenske Laboratory
814-865-2574

Degrees Conferred: Ph.D., M.S.

Senior Members of the Graduate Faculty
Paul Barton, Ph.D. (Penn State) *Assistant Professor of Chemical Engineering*
Ronald P. Danner, Ph.D. (Lehigh) *Professor of Chemical Engineering*
Thomas E. Daubert, Ph.D. (Penn State) *Professor of Chemical Engineering*
J. Larry Duda, Ph.D. (Delaware) *Professor of Chemical Engineering*
Alfred J. Engel, Ph.D. (Wisconsin) *Professor of Chemical Engineering*
John A. Frangos, Ph.D. (RIce) *Assistant Professor of Chemical Engineering*
Friedrich G. Helfferich, Dr.rer.nat. (Göttingen, Germany) *Professor of Chemical Engineering*
Robert L. Kabel, Ph.D. (Washington) *Professor of Chemical Engineering*
Richard D. La Roche, Ph.D. (Illinois) *Assistant Professor of Chemical Engineering*
John R. McWhirter, Ph.D. (Penn State) *Professor of Chemical Engineering*
Ramanathan Nagarajan, Ph.D. (SUNY-Buffalo) *Associate Professor of Chemical Engineering*
Jonathan Phillips, Ph.D. (Wisconsin) *Assistant Professor of Chemical Engineering*
John M. Tarbell, Ph.D. (Delaware) *Professor of Chemical Engineering*
James S. Ultman, Ph.D. (Delaware) *Professor of Chemical Engineering*
M. Albert Vannice, Ph.D. (Stanford) *Professor of Chemical Engineering*
James S. Vrentas, Ph.D. (Delaware) *Professor of Chemical Engineering*

Associate Members of the Graduate Faculty
Alfred Carlson, Ph.D. (Wisconsin) *Assistant Professor of Chemical Engineering*
Daniel White, Jr., Ph.D. (Florida) *Assistant Professor of Chemical Engineering*

Course offerings or research facilities are available in the following areas: applied thermodynamics, biomedical engineering, biotechnology, catalysis, polymer and colloid science, transport phenomena, tribology and lubrication.

Admission Requirements
Scores from the Graduate Record Examination (GRE), or from a comparable substitute examination accepted by a graduate program and authorized by the dean of the Graduate School, are required for admission. At the discretion of a graduate program, a student may be admitted provisionally for graduate study in a program without these scores. Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin*.

To be admitted, a student should be a graduate of an accredited major in chemical engineering or the equivalent. Graduates of other accredited engineering or physical science majors may be admitted but will be required to make up certain undergraduate deficiencies without graduate credit. Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

Master's Degree Requirements
A minimum of 30 graduate credits is required and must include at least 18 credits in the 500 and 600 series combined. A thesis is required. There is no communication or language requirement.

Continuous registration is required for all graduate students until the thesis or engineering report is approved.

Doctoral Degree Requirements
A minimum of 30 graduate course credits is required and must include a minimum of 15 credits of 500-series Chemical Engineering courses taken at the University. There is no communication or language requirement. The comprehensive examination consists of a written research proposal or project defended orally after it has been accepted.

Continuous registration is required for all graduate students until the thesis or engineering report is approved.

Other Relevant Information
The department wishes to have its graduate students begin their thesis research as soon as possible. Consequently, all new graduate students are matched to available research projects as soon as possible, usually within a month, after they join the department.

Student Aid
Graduate assistantships available to students in this program and other forms of student aid are described in the STUDENT AID section of the *Graduate Bulletin*.

CHEMICAL ENGINEERING (CH E)

401. Chemical Process Engineering (3)
407. Chemical Engineering Laboratory (3)
408. Chemical Engineering Laboratory II (2)
413. Mass Transfer Operations (3)
414. Kinetics and Industrial Chemistry (3)
415. Mathematical Modeling in Chemical Engineering (3)
416. Techniques of Process Design (3)
420. Cryogenic Engineering (3)
422. Modern Petroleum Technology — Processes and Products (3)
430. Nuclear Chemical Engineering (3)
431. Advanced Industrial Chemistry Applications (3)
441. Polymer Processing (3)
446. Introduction to Transport Phenomena (3)
448. Advanced Mass Transfer Operations (3)
450. Process Dynamics (3)
453. Thermodynamics for Chemical Engineers (3)
455. Chemical Reactor Design (3)
460. Chemical Engineering (4)
464. Design of Chemical Plants (3)
465. Design Projects in Chemical Engineering (1-6)
494. Research Projects in Chemical Engineering (1-6)
497. Special Topics (1-9)

507. Simulation and Modeling (3) Synthesis of subsystem and system models, emphasizing the generality of the principles for application to diverse physical and chemical processes.

509. Heat Transfer Applications (3) Advanced treatment of steady-state and transient conduction, convection, and radiation, with emphasis on numerical methods and design techniques. Prerequisite: an undergraduate course in heat transfer. *Daubert*

516. Methods of Process Design (3) Survey of mathematical techniques of chemical process design, with emphasis on economic choice and optimal decision making. *Engel*

524. Chemical Engineering, Application of Thermodynamics (3) Elements of thermochemistry and thermodynamics of greatest importance in chemical engineering.

535. Chemical Reaction Engineering (3) Optimal design of batch and continuous chemical reactors and reactor batteries; effect of mixing on reactor operation.

536. Heterogeneous Catalysis (3) Thermodynamics and kinetics of adsorption and reactions and solid surfaces, heat and mass transfer effects, theory and correlations in catalysis. Prerequisites: CHEM 451, 452. *Vannice*

544. General Transport Phenomena (3) Formulation and solution of transport problems involving momentum, heat, and mass transfer, with chemical engineering applications. Prerequisites: CH E 302, 413.

545. Transport Phenomena I (3) Momentum transport, laminar and turbulent flow, boundary layer analysis, non-Newtonian flow, mechanical energy balance, chemical engineering applications.

546. Transport Phenomena II (3) Heat and mass transfer, steady and unsteady state, coupling, molecular diffusion, moving boundaries, transfer coefficients, chemical engineering applications.

548. Multistage Mass Transfer Operations (3) Rigorous solution of complex problems in distillation, extraction, and absorption, including computer methods. Prerequisite: an undergraduate course in mass transfer.

550. Dynamics of Chemical Systems (3) Systems models; steady-state multiplicity; linear and nonlinear stability; oscillatory and chaotic states; multivariable and optimal; nonequilibrium thermodynamic stability. Prerequisite: CH E 450. *Tarbell*

596. Individual Studies (1-9)

597. Special Topics (1-9)

602. Supervised Experience in College Teaching (1-3 per semester, maximum of 6)

CHEMISTRY (CHEM)

GREGORY L. GEOFFROY, *Head of the Department*
152 Davey Laboratory
814-865-6553

Degrees Conferred: Ph.D., M.S.

Senior Members of the Graduate Faculty
David Allara, Ph.D. (UCLA) *Professor of Materials Science and Chemistry*
Harry R. Allcock, Ph.D. (London) *Professor of Chemistry*
James B. Anderson, Ph.D. (Princeton) *Professor of Chemistry*
Stephen J. Benkovic, Ph.D. (Cornell) *Professor of Chemistry*
Robert A. Bernheim, Ph.D. (Illinois) *Professor of Chemistry*
A. W. Castleman, Ph.D. (Polytechnic Institute of Brooklyn) *Professor of Chemistry*
Raymond L. Funk, Ph.D. (California) *Associate Professor of Chemistry*
Barbara J. Garrison, Ph.D. (California-Berkeley) *Professor of Chemistry*
Gregory L. Geoffroy, Ph.D. (California Tech.) *Professor of Chemistry*
L. Peter Gold, Ph.D. (Harvard) *Associate Professor of Chemistry*
Charles G. Haas, Jr., Ph.D. (Chicago) *Professor of Chemistry*
Gordon A. Hamilton, Ph.D. (Harvard) *Professor of Chemistry*
Julian P. Heicklen, Ph.D. (Rochester) *Professor of Chemistry*
William DeW. Horrocks, Jr., Ph.D. (MIT) *Professor of Chemistry*
Lloyd M. Jackman, Ph.D. (Adelaide) *Professor of Chemistry*
Joseph Jordan, Ph.D. (Hebrew University) *Professor of Chemistry*
Peter C. Jurs, Ph.D. (Washington) *Professor of Chemistry*
Frederick W. Lampe, Ph.D. (Columbia) *Professor of Chemistry*
John P. Lowe, Ph.D. (Northwestern) *Professor of Chemistry*
C. Robert Matthews, Ph.D. (Stanford) *Associate Professor of Chemistry*
Roy A. Olofson, Ph.D. (Harvard) *Professor of Chemistry*
Herman G. Richey, Jr., Ph.D. (Harvard) *Professor of Chemistry*
Ayusman Sen, Ph.D. (Chicago) *Associate Professor of Chemistry*
Maurice Shamma, Ph.D. (Wisconsin) *Professor of Chemistry*
William A. Steele, Ph.D. (Washington) *Professor of Chemistry*
Joseph J. Villafranca, Ph.D. (Purdue) *Professor of Chemistry*
Thomas Wartik, Ph.D. (Chicago) *Professor of Chemistry*
Steven M. Weinreb, Ph.D. (Rochester) *Professor of Chemistry*
Nicholas Winograd, Ph.D. (Case Western Reserve) *Professor of Chemistry*

Associate Members of the Graduate Faculty
Alan J. Benesi, Ph.D. (California-Berkeley) *Lecturer in Chemistry*
Andrew G. Ewing, Ph.D. (Indiana) *Assistant Professor of Chemistry*
Kenneth S. Feldman, Ph.D. (Stanford) *Assistant Professor of Chemistry*
Juliette T. Lecomte, Ph.D. (Carnegie-Mellon) *Assistant Professor of Chemistry*
Mark Maroncelli, Ph.D. (California) *Assistant Professor of Chemistry*
Przemyslaw Maslak, Ph.D. (Kentucky) *Assistant Professor of Chemistry*
Robert D. Minard, Ph.D. (Cornell) *Lecturer in Chemistry*

The Ph.D. program in Chemistry provides students with a broad background in one of the major areas of chemistry (analytical, biological, inorganic, organic, or physical) and intensive research experience culminating in the preparation of a formal thesis. The goal of the program is to prepare students

tor a variety of careers in academia, government, or industry. The exceptionally high quality of our laboratory and computer facilities enables us to provide students with outstanding research opportunities. Distinguished visiting scholars conduct informal discussions each Thursday at a departmental colloquium.

Admission Requirements

Scores from the Graduate Record Examination (GRE) are required for admission. In extenuating circumstances, a student may be admitted provisionally for graduate study in the program without these scores. Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin*.

For admission, at least integral calculus plus one year's work in general physics, organic chemistry, physical chemistry, and either analytical or inorganic chemistry are normally required. Students who have appropriate course backgrounds and who present a 2.50 average in all undergraduate courses in chemistry, physics, and mathematics will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

Master's Degree Requirements

The program of the M.S. candidate must include a total of at least 30 graduate-level course credits (CHEM 431, 451, 452, 457, 458, 489, and 500 may not be included in this credit count.) These 30 credits must be apportioned so that at least 18 credits are in the CHEM 400 and 500 series. (CHEM 589 credits *may not* be included in these 18 credits.)

Additional requirements of the M.S. program are that the candidate must write either a thesis or research report and must defend this thesis or report at an oral examination. The thesis or report will be accomplished under the sponsorship of a faculty member, and the candidate must schedule at least 6 credits of CHEM 600 (for a thesis) or CHEM 589 (for a research report) to fulfill this requirement. The candidate's attainments under a thesis or research report must be approved by a committee of at least three faculty members, one of whom will be the candidate's sponsor.

A knowledge of French, German, Japanese, or Russian equivalent to that gained by taking and passing two undergraduate courses in one of these languages is required.

Qualifying examinations in analytical, inorganic, organic, and physical chemistry will be given to all new students upon entrance in the fall semester. These cover subject matter at the level of the basic courses offered for the B.S. degree in chemistry at Penn State. For certification as an M.S. candidate, proficiency in two areas is required. These must include physical chemistry and the student's area of concentration. Such proficiency may be demonstrated either by (1) passing the area examination upon entrance, or (2) obtaining a grade of A or B in at least 3 credits of graduate-level course work in the area. The courses to be used to fulfill this latter option will be designated by the graduate counseling committee. This course work must be completed successfully during the student's first two semesters.

A final oral examination will be administered by a committee consisting of the student's research preceptor and two other faculty members. This examination is scheduled after the M.S. thesis or research report has been completed.

Doctoral Degree Requirements

Candidates for the Ph.D. degree in Chemistry must meet the following requirements established by the department faculty.

A knowledge of French, German, Japanese, or Russian equivalent to that gained by taking and passing two undergraduate courses in one of these languages is required.

A Ph.D. candidate shall be required to take a minimum of five 2- or 3-credit courses in chemistry at the 400-500 level (excluding CHEM 431, 451, 452, 457, 458, 489, and 500). Individual areas of concentration may specify one or more specific courses within this minimum requirement. The candidate's doctoral committee may require additional specific courses.

Qualifying examinations in analytical, inorganic, organic, and physical chemistry will be given to all new students upon entrance in the fall semester. These cover subject matter at the level of the basic courses offered for the B.S. degree in chemistry at Penn State. As a part of the requirements for certification as a Ph.D. candidate, each student will be expected to demonstrate proficiency in three areas of chemistry, including physical chemistry and the student's area of concentration. Such proficiency may be demonstrated either by (a) passing the area examination upon entrance, or (b) obtaining a grade of A or B in at least 3 credits of graduate-level course work in the area. The courses to be used to fulfill this latter option will be designated by the graduate counseling committee. This course work must be completed successfully during the student's first two semesters.

In order to qualify for the oral comprehensive examination, a Ph.D. candidate shall pass six cumulative examinations, two of which may be outside his or her area of specialization, during the first two years of residency. Cumulative examinations will be given monthly.

A Ph.D. candidate shall take the oral comprehensive examination during his or her first two and one-half years of residency.

Every Ph.D. candidate shall present at least one area or department seminar during the course of residency.

A final oral examination based on a defense of the doctoral thesis is required of all candidates.

Other Relevant Information

All candidates for advanced degrees must schedule CHEM 602, Supervised Experience in College Teaching, for 1 to 2 credits for at least one semester. This requirement may be waived or modified for students who have attained satisfactory competence in teaching as a result of prior experience.

Student Aid

Graduate assistantships available to students in this program and other forms of student aid are described in the STUDENT AID section of the *Graduate Bulletin*. It is important to note that department policy limits financial support *from department funds* to the *first two years* of graduate study of an M.S. candidate and to the *first five years* of graduate study of a Ph.D. candidate. Financial support beyond these periods is permitted from other than department funds, e.g., a research assistantship funded from an individual faculty member's research grant(s).

CHEMISTRY (CHEM)

400. Chemical Literature (1)
405. (NUC E 405) Nuclear and Radiochemistry (3)
408. (CMPSC 408) Computer Applications in Chemistry (3)
410. Inorganic Chemistry (3)
411. Inorganic Chemistry (3)
427. Instrumental Analysis (2)
428. Instrumental Analysis (2)
429. Instrumental Analysis (2)
431. Organic and Inorganic Preparations (3)
439. Structural Analysis of Organic Compounds (3)
448. Surface Chemistry (3)
*451-452. Physical Chemistry (3 each)
453. Thermodynamics of Chemical Systems (3)
454. Introduction to Quantum Chemistry (3)
455. Physical Chemistry of High Polymers (3)
*457. Experimental Physical Chemistry (1-2)
*458. Experimental Physical Chemistry (1-2)
463. Chemical Kinetics (3)
*489. Introduction to Chemical Research (1-10 per semester, maximum of 20)
496. Independent Studies (1-18)
497. Special Topics (1-9)

500. Seminar in Chemistry (1 per semester)

516-517. Inorganic Chemistry (3 each) Systematic treatment of inorganic chemistry in terms of modern concepts.

518. Special Topics in Inorganic Chemistry (3 per semester) Modern developments in specialized fields.

524. Electroanalytical Chemistry (3) Modern instrumental methods of analysis; electrochemistry.

525. Analytical Separations (3) Modern instrumental analysis, including chromatography and other separation methods.

526. Spectroscopic Analysis (3) Modern instrumental analysis, including absorption, emission, electronic, and magnetic spectroscopies.

527. Special Topics in Analytical Chemistry (2-12)

*Graduate credit not allowed for students majoring in Biochemistry, Chemistry, or Chemical Engineering.

531. Special Topics in Organic Chemistry (3-12) Prerequisite: CHEM 536.

534. Chemical Applications of Quantum Theory (3) A development of Molecular Orbital Theory up to the level of present-day usage in organic and inorganic chemistry.

535-536. Organic Reaction Mechanisms I and II (3 each) Reaction mechanisms and their determination by kinetic and nonkinetic methods. Reactive intermediates. Prerequisite: CHEM 439.

537. Synthesis in Organic Chemistry (3) Theory and methods of directed syntheses, including stereospecific and stereoselective schemes; biologically inspired syntheses. Prerequisite: CHEM 536.

539. Mechanistic Bioorganic Chemistry (3) Advanced organic reaction mechanisms, particularly those applicable to biological systems. Prerequisites: CHEM 535, BIOCH 401.

544. Chemical Thermodynamics (3) Development of thermodynamic theory, with special reference to common physical changes and chemical reactions. Prerequisite: CHEM 452.

545. Statistical Thermodynamics (3) The calculation of thermodynamic properties from molecular and spectroscopic data. Prerequisites: CHEM 453 or 544; CHEM 565.

560. Topics in Physical Chemistry (2-6)

563. Chemical Dynamics (3) Molecular dynamics of chemical reaction, energy transfer, and scattering. Reaction rate theory and experiment. Prerequisite: CHEM 565.

565. Quantum Chemistry I (3) An introduction to the principles of quantum mechanics and their application to chemistry. Prerequisite: CHEM 452.

566. Quantum Chemistry II (3) Modern techniques in quantum mechanics, with applications to problems in molecular structure and interactions. Prerequisite: CHEM 565.

567. Molecular Spectroscopy (3) Principles and methods of molecular spectroscopy and their applications to chemical problems. Prerequisite: CHEM 565.

571. Polymer Chemistry (3) The synthesis, reactions, and structure determination of high polymers.

589. Studies in Chemistry (1-9) Theoretical research, experimental research, or a critical survey of the literature in an area of chemistry.

597. Special Topics (1-9)

602. Supervised Experience in College Teaching (1-3 per semester, maximum of 6)

CIVIL ENGINEERING (C E)

MICHAEL S. BRONZINI, *Head of the Department*
212 Sackett Building
814-865-8391

Degrees Conferred: Ph.D., M.S., M.Eng.

Senior Members of the Graduate Faculty
David A. Anderson, Ph.D. (Purdue), P.E. *Professor of Civil Engineering*
Gert Aron, Ph.D. (California), P.E. *Professor of Civil Engineering*
Michael S. Bronzini, Ph.D. (Penn State), P.E. *Head; Professor of Civil Engineering*
Philip D. Cady, Ph.D. (Penn State), P.E., P.L.S. *Professor of Civil Engineering*
Mriganka M. Ghosh, Ph.D. (Illinois) *Professor of Civil Engineering*
William H. Gotolski, Ph.D. (Penn State), P.E. *Director, Engineering Advising Center; Professor of Civil Engineering*
David F. Kibler, Ph.D. (Colorado State), P.E. *Professor of Civil Engineering*
Walter P. Kilareski, Ph.D. (Penn State), P.E., P.L.S. *Associate Professor of Civil Engineering*
Thomas D. Larson, Ph.D. (Penn State), P.E. *Pennsylvania Professor of Government and Management; Professor of Civil Engineering*
David A. Long, Ph.D. (Penn State), P.E. *Professor of Civil Engineering*
Richard M. McClure, Ph.D. (Penn State), P.E. *Associate Professor of Civil Engineering*
Archibald J. McDonnell, Ph.D. (Penn State) *Professor of Civil Engineering*

Arthur C. Miller, Ph.D. (Colorado State), P.E. *Professor of Civil Engineering*
Joseph R. Reed, Ph.D. (Cornell), P.E. *Professor of Civil Engineering*
Raymond W. Regan, Ph.D. (Kansas), P.E. *Associate Professor of Civil Engineering*
Andrew Scanlon, Ph.D. (Alberta), P.E. *Professor of Civil Engineering*
H. Randolph Thomas, Ph.D. (Vanderbilt), P.E. *Professor of Civil Engineering*
Raymond E. Untrauer, Ph.D. (Illinois), P.E. *Professor of Civil Engineering*
Richard F. Unz, Ph.D. (Rutgers) *Professor of Environmental Microbiology*
Mian C. Wang, Ph.D. (California), P.E. *Professor of Civil Engineering*
Harry H. West, Ph.D. (Illinois), P.E. *Professor of Civil Engineering*
Jack H. Willenbrock, Ph.D. (Penn State), P.E. *Professor of Civil Engineering*

Associate Members of the Graduate Faculty
Thomas B. Davinroy, D.Eng. (California) *Associate Professor of Civil Engineering*
Steven Deutsch, Ph.D. (Penn State) *Senior Research Associate at the Applied Research Laboratory*
William J. Gburek, Ph.D. (Penn State) *Adjunct Associate Professor of Civil Engineering*
G. Warren Marks, Ph.D. (Illinois), P.L.S. *Associate Professor of Civil Engineering*
John M. Mason, Jr., Ph.D. (Texas A&M), P.E. *Associate Professor of Civil Engineering*
Ralph R. Mozingo, M.S. (Penn State) *Associate Professor of Civil Engineering*

Students may specialize in structures, hydraulics, hydrology, transportation engineering, traffic engineering, materials, construction, geotechnical, and environmental engineering, or combinations of these. Relevant courses are offered both by the Department of Civil Engineering and by other departments of the University.

Admission Requirements
Scores from the Graduate Record Examination (GRE) Aptitude Test (verbal, quantitative, and analytical) are required by the Department of Civil Engineering for completion of the admission process. Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin.*

Candidates normally should be graduates from an accredited program in engineering. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. Entering graduate students for whom English is not the first language are required to attain at least a 550 score on the TOEFL (Test of English as a Foreign Language) examination. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

Degree Requirements
Continuous registration is required for all graduate students until the thesis or engineering report is approved.

A thesis is required for the M.S. degree. An engineering report is required for the M.Eng. degree. In addition to demonstrating competence in English, each candidate for the Ph.D. degree must meet a foreign language or communication skills requirement established by the department.

Other Relevant Information
Students in this program may elect the dual-title degree program option in Operations Research for the Ph.D. and M.S. degrees (see page 326).

See also Environmental Engineering.

Student Aid
In addition to the fellowships, traineeships, graduate assistantships, and other forms of financial aid described in the STUDENT AID section of the *Graduate Bulletin,* the following awards typically have been available to graduate students in this program:

W. S. Elliott Fellowship — Available to a graduate student who is a graduate of Penn State and is interested in engineering research; stipend variable. Apply to Office of the Dean, College of Engineering, 101 Hammond Building.

Fred B. Rooney Transportation Scholarship — Established by the Seley Foundation and available to a graduate student in civil engineering who is a permanent resident of either Lehigh or Northampton County, Pennsylvania, and who is specializing in transportation engineering. Apply to the Department of Civil Engineering, 212 Sackett Building.

J. Waldo Smith Hydraulic Fellowship — Established by the American Society of Civil Engineers, Board of Direction, for a graduate student who is preferably an associate member of ASCE.

Awarded every third year; $2,000 for one full academic year, plus a maximum of $1,000 for research equipment, preferably in the field of experimental hydraulics. More information can be obtained from the Department of Civil Engineering, 212 Sackett Building.

Harry F. Thomson Scholarship — Established by the American Concrete Institute for graduate study in the field of concrete. The scholarship is open to any student who is completing studies toward the bachelor's degree or who has received a bachelor's degree from an accredited engineering program. The applicant must be accepted for graduate study of concrete, involving design, materials, construction, or any combination of these subject areas, at a recognized university or college at the time of the award. Information and applications can be obtained from the Department of Civil Engineering, 212 Sackett Building. Application deadline is February 1.

CIVIL ENGINEERING (C E)

400. Seminar (1-3)
411. Boundary Surveying (3)
412. Photogrammetry (3)
413. Airphoto Interpretation (3)
421. Highway Facilities Design (3)
423. Highway Systems Operations (3)
424. Civil Engineering Materials (3)
428. Railroad Engineering (3)
431. Civil Engineering Construction (3)
432. Construction Project Control (3)
433. Residential Subdivision Design and Construction (3)
446. Advanced Soil Mechanics I (3)
447. Structural Analysis by Matrix Methods (3)
448. Advanced Structural Design (3)
449. Design of Prestressed and Reinforced Concrete Structures (3)
451. Advanced Hydrology (3)
462. Open Channel Hydraulics (3)
465. River and Waterways Engineering (3)
471. Environmental Sanitation (3)
472. Water Pollution Control Processes (3)
473. Water Quality Management (3)
474. Management of Water Pollution Control Processes (3)
475. (E R M 475) Water Quality Chemistry (3)
476. Solid Waste Management (3)
477. Industrial Hazardous and Residual Waste Management (3)
479. Environmental Microbiology Laboratory (1)
494. Senior Thesis (1-9)
496. Independent Studies (1-18)
497. Special Topics (1-9)

511. Engineering Soil Characteristics (3) Applications of physico-chemical principles in soil engineering; soil composition; factors influencing engineering soil properties. Prerequisite: C E 244.

512. Soil Mechanics II (2-5) Evaluation of strength parameters and compressibility of soils; elastic analysis of stress and strain; techniques of forecasting foundation settlement; slope stability analysis. Prerequisite: C E 446.

513. Advanced Foundation Engineering (3) Practical applications of soil mechanics principles to geotechnical engineering problems; dewatering techniques; design of deep foundations and retaining structures. Prerequisite: C E 244.

520. Pavement Design (3) Fundamental principles; properties of pavement components; design tests; design of flexible pavements; design of rigid pavements; pavement evaluation and strengthening. Prerequisites: C E 224, 244.

521. Transportation Networks and Systems Analysis (3) Techniques of transportation network, user, stochastic user, and variable demand equilibrium; transportation activity system; computer simulation techniques and forecasting methods. Prerequisite: 3 credits in computer science.

522. Highway Operations (3) Theory and application of traffic signals and networks; capacity analysis of intersection and highway sections; computer evaluation programs; geometric design interactions. Prerequisite: C E 423.

523. Analysis of Transportation Demand (3) Theories of travel behavior, least squares and maximum likelihood, estimation methods, continuous dependent variable models, utility maximization, discrete econometric techniques. Prerequisite: 3 credits in probability and statistics.

524. Advanced Problems in Civil Engineering Materials (2-6) Study in the literature and by laboratory investigation of selected topics on field-controlled civil engineering materials. Prerequisite: C E 424.

*525. Airport Planning and Design (3) Aircraft characteristics; aeronautical demand; site selection; airport configuration; capacity analysis; design of landing and terminal areas. Prerequisite: C E 221.

531. Legal Aspects of Engineering and Construction (3) Basic legal doctrines, contractual relationships between parties, analysis of construction contract clauses, contract performance, and professional practice problems. Prerequisite: C E 431.

532. Heavy Industrial Construction (3) Planning, engineering, and construction of industrial facilities, including design responsibilities; civil, mechanical, and electrical construction; start-up and testing.

539. Approximate Methods of Structural Analysis (3) Structural analysis through the application of initial-value methods, Newmark's method, Fourier series, finite difference techniques, and work and energy procedures. Prerequisite: C E 240.

540. Structural Analysis by Classical Methods (3) Analysis of continuous trusses and beams, frames, arches, grids, curved beams, suspension systems, and space frames. Prerequisite: C E 240.

541. Structural Analysis (3) Theory of various finite elements as applied to civil engineering structures. Term paper required. Prerequisite: C E 447.

544. Behavior and Design of Reinforced Concrete Members (3) Study of flexure, shear, torsion, compression, combined forces, shrinkage, creep, and deflections applied to beams and frames.

545. Design of Metal Structures (3) Steel, aluminum members; flexible connections; composite, hybrid, prestressed beams; tension-field beams; buckling; plastic analysis, design; test data; timber design. Prerequisite: C E 342.

546. Reinforced Concrete Slabs (3) Behavior, analysis, and design of floor systems; elastic, ACI Code method, yield line theory; two-way, flat slab, flat plate. Prerequisite: C E 341.

548. Structural Design for Dynamic Loads (3) Dynamic behavior of structural systems of one and more degrees of freedom; earthquake, blast-resistant analysis, and design of structures. Prerequisites: E MCH 012, C E 240.

550. Engineering Construction Management (3) Management fundamentals for construction contracting; organization, project planning, scheduling and control, bonding and insurance, labor legislation and regulation, cost and control. Prerequisite: C E 431.

551. Probability, Statistics, and Decision Analysis in Water Resources (3) Application of statistics, probability theory, stochastic modeling, and decision theory in the analysis, design, and management of water resources systems. Prerequisites: C E 351; introductory probability and statistics.

552. Civil Engineering Systems Analysis (3) Application of optimization techniques to decision-making processes in hydrologic, structural, and other civil engineering design alternatives. Prerequisite: C E 230.

553. Planning Multipurpose Hydrologic Systems (3) Study of multipurpose hydrologic schemes within a social, economic, and political framework. Prerequisites: C E 451, ECON 014.

554. Urban Hydrology (3) Several hydrograph methods. Design storm and IUH application; airport drainage; flood plains; impact of urbanization upon groundwater and sediment. Prerequisite: C E 451.

*This course includes from one to several trips for which an additional charge will be made.

560. Dimensional Analysis and Theory of Models (3) Principles of dimensional analysis and similitude, with engineering applications primarily to problems in hydromechanics. Prerequisite: C E 261.

564. Hydraulic Engineering Design (3) Design and analysis of selected units of a typical hydraulic engineering project. Prerequisite: C E 362.

570. Environmental Aquatic Chemistry (3) Speciation, reactivity, and distribution of contaminants in water, with emphasis in inorganic chemicals. Prerequisite: C E 475.

571. Physical-Chemical Treatment Processes (3) The theory of physical-chemical processes used in the treatment of potable water and municipal and industrial wastewaters. Prerequisite: C E 472 or 475.

572. Biological Treatment Processes (3) The theory of biological processes used in the treatment of municipal and industrial wastewaters. Prerequisite or concurrent: C E 475, MICRB 400.

574. Laboratory Analyses in Water Quality Control (3) Experiments illustrating current chemical and biochemical methods of water and waste treatment and analytical methods used in research and control. Prerequisite: C E 475.

575. Industrial Waste Treatment (2) Surveys and data analysis; use of unit processes to meet regulatory agency requirements; disposal of gaseous and solid residues. Prerequisite: C E 472.

577. Treatment Plant Design (1-6) Design of works for the treatment of water and wastewater for municipalities and industries. Prerequisites: C E 472; 3 credits in hydraulics.

579. (MICRB 529) Environmental Pollution Microbiology (3) Fundamentals of microorganisms in water and wastewater treatment; indicators of pollution; activities of microorganisms in polluted waters, including biogeochemical cycles. Prerequisite: MICRB 400.

580. Stream and Estuarine Analysis (3) Development and application of water quality models for rivers, lakes, and estuaries; biological and chemical reactions in natural systems. Prerequisite: C E 370.

590. Colloquium (1-3)

596. Individual Studies (1-9)

597. Special Topics (1-9)

602. Supervised Experience in College Teaching (1-3 per semester, maximum of 6)

COMMUNICATION DISORDERS (CMDIS)

HARVEY R. GILBERT, *Acting Head, Department of Communication Disorders*
109 Moore Building
814-863-2010

Degrees Conferred: Ph.D., M.S., M.Ed.

Senior Members of the Graduate Faculty
Thomas A. Frank, Ph.D. (Wisconsin) *Associate Professor of Communication Disorders*
Alan J. Gallaher, Ph.D. (Northwestern) *Assistant Professor of Communication Disorders*
Harvey R. Gilbert, Ph.D. (Wisconsin) *Associate Professor of Speech Science and Communication Disorders*
Philip M. Prinz, D.Ed. (Boston) *Associate Professor of Communication Disorders*
Frederick F. Weiner, Ph.D. (Wayne State) *Associate Professor of Communication Disorders*

Associate Members of the Graduate Faculty
Gordon W. Blood, Ph.D. (Bowling Green) *Assistant Professor of Communication Disorders*
Ingrid M. Blood, Ph.D. (Bowling Green) *Assistant Professor of Communication Disorders*
Stephen M. Camarata, Ph.D. (Purdue) *Assistant Professor of Communication Disorders*

The general goal of the program is to prepare competent professionals to habilitate and rehabilitate people who have speech, language, or hearing problems. Students may specialize in speech-language pathology or audiology.

Facilities for student training and research include in-house clinical therapy and diagnostic services, laboratories in speech science and audiology, and affiliated schools and clinics. The program enjoys academic, research, and clinical relationships with a number of related programs at Penn State and draws upon academic work from related areas as part of the graduate training in communication disorders. Preparation is given for school and professional certifications. The program is approved by the American Board of Examiners in Speech Pathology and Audiology (ABESPA) for speech pathology and audiology for both academic training and clinical services. Graduate study requires a full-time internship experience, ordinarily at an external site.

Admission Requirements

Scores from the Graduate Record Examination (GRE), or from a comparable substitute examination accepted by a graduate program and authorized by the dean of the Graduate School, are required for admission. At the discretion of a graduate program, a student may be admitted provisionally for graduate study in a program without these scores. Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin*.

Approximately 36 credits are required for admission, distributed among speech pathology, audiology, speech science, education, and psychology, and including a course in statistics. Students entering without an undergraduate program in the field may be required to take additional makeup work.

Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

Usually students earn a master's degree in communication disorders prior to being considered for doctoral study, although persons with master's degrees in other fields will be considered for a doctoral program that includes studying necessary background information.

Master's Degree Requirements

The master's degrees require a minimum of 50 graduate credits beyond admission standards. Students usually earn 55 to 65 credits to complete a degree, over four semesters and a summer of study.

Candidates for the Master of Education degree must take 6 credits in a field of professional education.

There is a nonthesis option for the Master of Science degree, requiring a paper and additional course credits in lieu of a thesis. The master's program of study provides course work and practicum for advanced or professional-level certification.

Doctoral Degree Requirements

The Doctor of Philosophy degree normally requires a master's degree in communication disorders or a related field, plus a minimum of two years of advanced study, and presentation and oral defense of a research-based dissertation.

The communication and foreign language requirement is a minimum of 6 credits of statistics beyond the first course, plus 9 credits selected from among statistics, technical writing, computer science, research design, or a foreign language.

Two research exercises, one of which is used for doctoral candidacy evaluation early in the doctoral program, are required prior to the dissertation. Comprehensive written examinations lasting about two and a half days in the areas of a student's interest and an optional minor field examination, plus a follow-up oral examination prior to dissertation, are required.

Details of a student's doctoral program are determined by the doctoral committee.

Student Aid

In addition to the fellowships, traineeships, graduate assistantships, and other forms of financial aid described in the STUDENT AID section of the *Graduate Bulletin,* the following awards typically have been available to graduate students in this program:

U.S. Rehabilitation Services Administration Traineeships in Speech Pathology and Audiology (7) — Provides tuition and a stipend. Apply to the Communication Disorders program.

USOE Master's Level Training — Provides tuition and a stipend. Apply to the Communication Disorders program.

USOE Preparation of Leadership Personnel for Doctoral Candidates — Provides tuition and a stipend. Apply to the Communication Disorders program.

COMMUNICATION DISORDERS (CMDIS)

400. Developmental Considerations in the Assessment and Treatment of Language Disorders (3)
430. Introduction to Audiology (4)
433. Aural Rehabilitation (3)
434. Electronystagmography (2)
440. (SPLED 440) Survey of Speech and Hearing Disorders (3)
442. Speech Pathology I (3)
444. Speech Pathology II (4)
445. Professional Programs and Relationships (3)
459. Principles of Clinical Management in Communication Disorders (2)
460. Theoretical Bases of Teaching Speech to the Hearing Impaired (3)
462. Clinical Bases of Language Disorders (2)
463. Teaching Language to the Hearing Impaired (3)
464-465. Teaching School Subjects to the Deaf (2 each)
468. Manual Communication II (2)
469. Manual Communication III (2)
495A. Speech Therapy Practicum (1-6)
495B. Hearing Impairment Practicum (1-5)
495C. Hearing Impairment Internship (6-15)
496. Independent Studies (1-18)
497. Special Topics (1-9)

500. Research Methods in Communication Disorders (1) Methodology necessary for understanding and conducting research in communication disorders. Prerequisites: 15 credits in communication disorders.

515. Application of Physiological and Acoustical Concepts of Speech Pathology and Audiology (4) Application of practical and theoretical concepts in neurology, physiology, and acoustics to communication disorders, with implications for clinical therapy. Prerequisites: 6 credits in speech science; 6 credits in speech pathology and audiology.

517. (LING 517) Theoretical Bases of Language Disorders in Children and Adults (3) Application of linguistic theory to the understanding of communication disorders, with clinical implications for speech and language therapy. Prerequisites: 12 credits in communication disorders or related fields, including a course in language acquisition.

522. (SPCOM 522) Speech Perception (3) Transformation of linguistic units into acoustic speech signals, theories of speech perception, and auditory processing of the speech signal. Prerequisites: SPCOM 410, 431, 520.

531. Hearing Aids (3) Hearing aid circuitry, electroacoustic characteristic measurement, and evaluation techniques and procedures for infants, children, and adults. Prerequisites: CMDIS 535, 567.

532. Acoustical Instruments for Hearing (3) Acoustical instrumentation used for research in hearing, programs of hearing conservation, and noise control, including clinical and industrial applications. Prerequisites: 6 credits in acoustics, audiology, experimental psychology, or speech science at the 400 level.

533. Speech Audiometry (3) Techniques, interpretation, and differential diagnosis of hearing ability employing speech and speech-like materials in children and adults. Prerequisites: ACS 401, CMDIS 430, 433; 6 additional credits in communication disorders.

534. Noise and Hearing (3) Noise-induced hearing problems; interference with communication; annoyance and community problems caused by acoustic energy; regulations and standards. Prerequisites: 6 credits at the 400 level in acoustics, audiology, experimental psychology, or speech science.

535. Pure Tone Audiometry (4) Techniques, interpretation, and differential diagnosis of hearing ability by pure tone and related audiometric techniques. Prerequisites: CMDIS 430, 433, ACS 401; 6 credits in speech pathology and audiology.

540. Phonological Disabilities (3) Speech-sound production disorders in children and adults; methods of examination, diagnosis, and treatment. Prerequisite: CMDIS 442, 495A.

541. The Voice and Its Disorders (3) Physical, physiological, and psychological bases of voice production; causes, nature, and symptoms of its disorders; current clinical methods in voice improvement. Prerequisites: CMDIS 444, 495A.

542. Stuttering (3) Modern theories of causes of disorders of rhythm; methods of examination, diagnosis, and treatment. Prerequisites: CMDIS 442, 495A.

543. Diagnostic Procedures in Speech Pathology (3) Clinical instrumentation; case history taking; examination procedures and materials used in diagnosing speech disabilities; interpretation of findings; report preparation. Prerequisites: 15 credits in communication disorders.

544. Cleft Palate (3) Anatomy, physiology, embryology, and growth of the palate and contiguous structures; etiology, diagnosis, habilitation of cleft palate problems. Prerequisite: CMDIS 444.

545. Neuromotor Disorders of Speech (3) Etiology and symptomatology of dysarthric and apraxic speech; diagnosis, treatment, and the team rehabilitative program approach to these disorders. Prerequisite: CMDIS 444 or 515 or SPCOM 431.

546. Language Disorders in Adults (3) Nature, etiology, diagnosis, and management of language disorders in adults. Prerequisites: 9 credits in speech pathology and audiology or related fields such as psychology, linguistics, or human development.

547. (SPLED 547) Language Disorders in Children (2) Nature, etiology, diagnosis, and management of language disorders in children. Prerequisites: CMDIS 400; 6 credits in communication disorders or related fields such as psychology, linguistics, or human development.

550. Seminar in Communication Disorders (1-6) Advanced study of special problems and new developments in communication disorders. Prerequisites: 10 credits in communication disorders.

560. Recent Developments in Education of the Deaf (2-6) In-depth seminar-style study of communication disorders associated with deafness, and advanced and experimental attempts at remediation. Prerequisites: 8 credits in education of the deaf or audiology; CMDIS 430, 433; 3 credits in child development or learning theory.

561. Clinical Procedures for Teaching Speech to the Hearing Impaired (3) An applications course providing demonstrations of techniques and practices, and instruction on how to apply such information in therapeutic situations. Prerequisite: CMDIS 460.

565. Integrating Language and Reading for Hearing Impaired Children (3) Theoretical bases and practical applications of an integrated approach to language and reading instruction for hearing impaired children. Prerequisites: CMDIS 463, RCLED 400.

566. Effects of Hearing Impairment on Cognitive and Social Development (3) Effects of hearing impairment on developmental, educational, social, and vocational adjustment; assisting the hearing impaired toward improved life adjustment. Prerequisites: CMDIS 430, 433.

567. Audiology for Hearing and Speech Clinicians (3) Etiology, measurement, and differential diagnosis of hearing loss; overview of aural rehabilitation, including hearing aids and auditory training systems. Prerequisites: CMDIS 430, 433; 6 credits in speech pathology and audiology.

568. Linguistic Aspects of American Sign Language (3) Study of the linguistic principles of American sign language, including syntactic, nonphonological, semantic, and pragmatic aspects. Prerequisite: CMDIS 468.

572. Psychoacoustics in Communication Disorders (4) Perceptual phenomena of normal audition supported by reviews of methods and principles of psycho-physical measurement and of hearing theory. Prerequisites: 6 credits of acoustics or communication disorders.

573. Physiological Acoustics in Communication Disorders (4) Overview of fundamental acoustics and application to anatomy and physiology of normal auditory systems. Prerequisites: 6 credits of acoustics or communication disorders.

574. Pediatric Audiology (3) Etiology, differential diagnosis, habilitation, and rehabilitation of hearing loss associated with infants, preschool, and school-age children. Prerequisite: CMDIS 535 or 567.

575. Special Audiological Tests (3) Theory, administration, and interpretation of special audiological tests to determine the site of lesion of a hearing loss. Prerequisites: CMDIS 533, 535.

595A. Speech Therapy Practicum (1-6) Theoretical and clinical rationale of therapy; professional role and relationships; therapy procedures, individual and group; evaluation of process and outcomes. Prerequisites: CMDIS 442, 495A.

595B. Hearing Impairment Practicum (1-6) Theoretical and clinical rationale of working with hearing impaired, professional role and relationships, therapy procedures, evaluation of process and outcomes. Prerequisite: CMDIS 459B.

595C. Speech Therapy Internship (7-15) Full-time internship experience in speech therapy and diagnostic procedures at an off-campus site. Prerequisites: 30 credits in communication disorders.

595D. Hearing Impairment Internship (7-15) Full-time internship experience in procedures for teaching the hearing impaired at an off-campus site. Prerequisites: 30 credits in communication disorders.

595E. Audiology Practicum (1-5) Prerequisite: CMDIS 531.

595F. Audiology Internship (7-15) Full-time internship experience in audiologic procedures at an off-campus site selected by the Communication Disorders program staff. Prerequisites: 30 credits in communication disorders.

595G. Speech Diagnostics Practicum (1-3) Supervised practice in interviewing, counseling, speech evaluation, and synthesis of psychological, medical, and audiological data in speech diagnosis; report writing. Prerequisites: CMDIS 444, 495A.

596. Individual Studies (1-9)

597. Special Topics (1-9)

602. Supervised Experience in College Teaching (1-3 per semester, maximum of 6) Prerequisites: 40 graduate credits in communication disorders.

COMMUNITY SYSTEMS PLANNING AND DEVELOPMENT (CSP D)

STANLEY P. MAYERS, JR., *Chair of Graduate Programs in Community Systems Planning and Development*
115 Human Development Building
814-863-2859

Degrees Conferred: Ph.D., M.S.

Senior Members of the Graduate Faculty
Thomas J. Bernard, Ph.D. (SUNY) *Associate Professor of Administration of Justice*
Bruce Bullington, Ph.D. (California) *Associate Professor of Criminal Justice*
Frederick R. Eisele, Ph.D. (NYU) *Associate Professor of Social Policy*
Peter B. Everett, Ph.D. (North Carolina) *Associate Professor of Man-Environment Relations*
Walter E. Freeman, Ph.D. (Michigan State) *Professor of Human Development*
Larry Gamm, Ph.D. (Iowa) *Associate Professor of Health Administration*
Daniel E. Georges-Abeyie, Ph.D. (Syracuse) *Associate Professor of Administration of Justice*
Lynne I. Goodstein, Ph.D. (CUNY) *Associate Professor of Administration of Justice*
Drew Hyman, Ph.D. (California) *Associate Professor of Community Development*
Philip Jenkins, Ph.D. (Clare) *Associate Professor of History of Justice*
Daniel Katkin, J.D. (Columbia) *Professor of Law*
John H. Kramer, Ph.D. (Iowa) *Associate Professor of Criminal Justice*
M. Powell Lawton, Ph.D. (Columbia) *Adjunct Professor of Human Development*
Stuart H. Mann, Ph.D. (Case Western Reserve) *Professor of Operations Research*
Stephen D. Mastrofski, Ph.D. (North Carolina) *Assistant Professor of Administration of Justice*
Joe A. Miller, Ph.D. (Michigan State) *Associate Professor of Community Development*
Arthur H. Patterson, Ph.D. (Northwestern) *Associate Professor of Environment and Behavior*

Marshall W. Raffel, Ph.D. (Victoria) *Professor of Health Planning and Administration*
R. Richard Ritti, Ph.D. (Cornell) *Professor of Organizational Behavior*
Bruce C. Stuart, Ph.D. (Washington State) *Associate Professor of Health Planning and Administration*

Associate Members of the Graduate Faculty
J. Gregory Carroll, Ph.D. (Cornell) *Associate Professor of Health Planning and Administration*
Sidney Cohn, Ph.D. (North Carolina) *Professor of Urban Design*
H. A. Divine, Ph.D. (Washington) *Professor of Hotel, Restaurant, and Institutional Management*
Earl S. Elliott, Ed.D. (Kansas) *Assistant Professor of Human Development*
Frederick E. Fisher, Ph.D. (Southern California) *Associate Professor of Community Development*
Carolyn Lambert, Ph.D. (Tennessee) *Associate Professor of Food Service Administration*
Stanley P. Mayers, Jr., M.P.H. (Pennsylvania) *Professor of Health Care Planning*
William H. Parsonage, M.A. (South Dakota) *Associate Professor of Administration of Justice*

This interdisciplinary program provides instruction in content and in research and decision-making methods related to the coordinated planning, development, management, and evaluation of a range of community systems and services in three professional areas: administration of justice, health planning and administration, and community planning and development.

The aim of the program is to build the knowledge base, along with the research, policy analytic, and planning skills, necessary to analyze major community subsystems, identify community dysfunctions, and develop strategies of intervention, policies, and programs responsive to the problems and developmental opportunities of communities. Graduates will develop skill in working with various community stakeholder groups and institutions to develop, facilitate, and evaluate interventions that lead to improvement in the quality of community life in various sectors.

The community systems planning and development curriculum concentrates on basic grounding in the processes and structure of community systems, the dimensions of community, the principles of community organizational behavior, and patterns of interorganizational and intergovernmental relations. In addition, the curriculum provides a basis for understanding the processes of planned change, as well as the tools for analysis, planning, and intervention. On this foundation the community systems student builds a professional emphasis in health, justice, or community planning and development.

The M.S. program prepares individuals for professional-level work in one of the three professional areas represented in the program. Doctoral candidates develop a greater depth of understanding of a range of community systems, services, and institutions, as well as specialized research and scholarly competence related to a particular component.

Graduates of the program are prepared to assume responsible and rewarding careers in both professional and academic settings. Many serve as directors of health, justice, community planning, or social service agencies; others pursue careers in consulting, research and development, or the provision of direct services in the public and private sectors. Some doctoral graduates choose careers as professors in health administration, criminal justice, or urban and community planning fields at major centers of learning in the United States and abroad.

Admission Requirements
Scores from the Graduate Record Examination (GRE), or from a comparable substitute examination accepted by a graduate program and authorized by the dean of the Graduate School, are required for admission. At the discretion of a graduate program, a student may be admitted provisionally for graduate study in a program without these scores. Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin*.

Preference will be shown to applicants who have a broad background in the social sciences. Proficiency in quantitative skills such as mathematics and statistics is also desirable. In general, a 3.00 junior-senior average is expected of applicants, but consideration will be given to prior graduate education and professional work experience.

Degree Requirements
A thesis or professional paper is required for the M.S. degree. The communication requirements for the Ph.D. can be satisfied by demonstration of proficiency through examination in a foreign language or a set of computer languages.

Student Aid
Graduate assistantships available to students in this program and other forms of student aid are described in the STUDENT AID section of the *Graduate Bulletin*.

COMMUNITY SYSTEMS PLANNING AND DEVELOPMENT (CSP D)

500. Introduction to Community Systems Planning and Development (3) Introduction to applied general systems theory; applications to analysis of community systems and to the planning of community human services.

501. Community Systems: Structure and Processes (3) Classic and contemporary community organization theory, social planning and change, decision making, human services planning and action, community action, community research.

503. (H P A 503) Understanding Organizational Behavior (3) A systematic application of the principles of organizational behavior to understanding professional roles in human service organizations.

504. (H P A 504) Interorganizational Relations (3) Interorganizational concepts and their application to analysis of policies, programs, and service delivery concerns involving health and human service organizations. Prerequisite: CSP D 503.

505. (H P A 505) Processes of Planned Change (3) Exploration of diagnostic and intervention strategies employed in planned change in health and human services organizations and programs.

516. Forecasting Methods and Social Policy Planning (3) Analysis of predictive methods for forecasting social change. Prerequisites: ECON 405, STAT 200.

520. Health Care Organization (3) Examination of health systems, organization, financing, and evaluation; trends, problems, and issues.

522A. (H P A 522A) Health Care Technology: Processes of Health and Disease (1) A review of the processes of health and disease, measurements, diagnostic criteria, and intervention strategies.

522B. (H P A 522B) Health Care Technology: The Technologies of Prevention (1) Health promotion and disease prevention from a technologic perspective, including physiologic, behavioral, and social/institutional technologies.

522C. (H P A 522C) Health Care Technology: The Technologies of Therapy and Rehabilitation (1) Technologic intervention in disease processes and rehabilitation: implications for clinical care, institutional management, and health sector planning.

524. (H P A 524) Management of Health Services Organizations (3) A systematic study of the roles of health services managers and the organizational and environmental context within which they work. Prerequisites: CSP D 503, 504.

525. (H P A 525) Hospital and Health Services Administration (3) A study of decision making in hospitals and health organizations; the process of decision making, incorporating various techniques and strategies. Prerequisites: CSP D 520, 524, 535, Q B A 511.

527. (H P A 527) Approaches to Health Planning (3) A systematic exploration of approaches to health planning and an application of health planning techniques. Prerequisite: CSP D 531.

531. (H P A 531) Health Problem Analysis (3) Logic of empirical inquiry in study of community problems in health. Integration of theory and practice, technical data and values.

535. (H P A 535) Financial Management in Health Institutions (3) Financial environment of health institutions; financial aspects of management decision making; emphasis on revenue sources, budgeting, and cost control.

536. (H P A 536) Health Law (3) The legal process as it applies to the health administrator, health organization, medical provider, and patient. Prerequisite: CSP D 520.

540. Values and Goals in the Administration of Justice (3) The justice system from perspective of clientele, service personnel, and the system. Meeting service requirements in community and institutional settings.

541. Social Processes in Crime and the Administration of Justice (3) The development of crime and justice systems in light of theories of conflict and consensus.

542. Administration of Criminal Justice Agencies (3) Administration and management techniques applied to justice settings, including decision making, communication, and career development.

543. Legal Issues in Human Services Administration (3) Examination of constitutional and administrative law principles relevant to the administration of human service agencies.

560. Issues and Trends in the Development of Social Welfare Services (3-6) Examination of selected issues affecting the development of social welfare functions and services.

588. (PUB A 588) Criminal Justice Administration Seminar (3) Administration of criminal justice systems; police, courts, and corrections in the context of public safety, human services, and multijurisdictional systems.

590. Colloquium (1-3)

596. (H P A 596) Individual Studies (1-9)

597. (H P A 597) Special Topics (1-9)

602. Supervised Experience in College Teaching (1-3 per semester, maximum of 6)

COMPARATIVE LITERATURE (C LIT)

CAROLINE D. ECKHARDT, *In Charge of Graduate Programs in Comparative Literature*
N433 Burrowes Building
814-863-0589

Degrees Conferred: Ph.D., M.A.

Senior Members of the Graduate Faculty
John A. Balaban, M.A. (Harvard) *Professor of English*
Samuel P. Bayard, M.A. (Harvard) *Professor Emeritus of English and Comparative Literature*
Michael H. Begnal, Ph.D. (Washington) *Professor of English and Comparative Literature*
Ernst A. Ebbinghaus, Ph.D. (Marburg) *Professor of German*
Caroline D. Eckhardt, Ph.D. (Michigan) *Professor of English and Comparative Literature*
Thomas A. Hale, Ph.D. (Rochester) *Associate Professor of French and Comparative Literature*
Alan E. Knight, Ph.D. (Yale) *Professor of French*
W. LaMarr Kopp, Ph.D. (Penn State) *Professor of German*
Arthur O. Lewis, Ph.D. (Penn State) *Professor Emeritus of English*
Robert F. Lima, Jr., Ph.D. (NYU) *Professor of Spanish and Comparative Literature*
Charles W. Mann, Jr., M.L.S. (Rutgers) *Professor of English*
Terry J. Peavler, Ph.D. (California) *Associate Professor of Spanish and Comparative Literature*
Daniel Walden, Ph.D. (NYU) *Professor of English*
Stanley Weintraub, Ph.D. (Penn State) *Research Professor of English*
Paul West, M.A. (Columbia) *Professor of English and Comparative Literature*

Associate Members of the Graduate Faculty
Mary Barnard, Ph.D. (Michigan) *Assistant Professor of Spanish and Comparative Literature*
Thomas O. Beebee, Ph.D. (Michigan) *Assistant Professor of Comparative Literature and German*
Patrick G. Cheney, Ph.D. (Toronto) *Assistant Professor of English*
Earl Fitz, Ph.D. (CUNY) *Associate Professor of Spanish and Comparative Literature*
Robert Ginsberg, Ph.D. (Pennsylvania) *Professor of Philosophy*
Stephen R. Grecco, M.F.A. (Yale) *Associate Professor of English*
Kathryn Grossman, Ph.D. (Yale) *Associate Professor of French*
Linda J. Ivanits, Ph.D. (Wisconsin) *Assistant Professor of Russian*
Christiane P. Makward, Docteur es Lettres (Paris) *Associate Professor of French*
John W. Moore, Jr., Ph.D. (Stanford) *Assistant Professor of English*
Angelita D. Reyes, Ph.D. (Iowa) *Assistant Professor of Comparative Literature and English*
Peter H. Schneeman, Ph.D. (Minnesota) *Associate Professor of English and Comparative Literature*
Gerhard F. Strasser, Ph.D. (Brown) *Assistant Professor of German*
Kenneth A. Thigpen, Ph.D. (Indiana) *Associate Professor of English and Comparative Literature*
Emily Toth, Ph.D. (Johns Hopkins) *Associate Professor of English*
Vincent Yang, Ph.D. (Rutgers) *Assistant Professor of Comparative Literature and Chinese*

Graduate programs in Comparative Literature are designed to permit advanced study in several departments along with integrative courses in the Department of Comparative Literature. Both the M.A. and the Ph.D. combine a small core of comparative literature requirements with courses in national literatures and further comparative literature courses, according to each student's interests. For example, programs of study can concentrate on such topics as genres, themes, periods, movements,

folklore, criticism, and the links between literature and related fields such as theatre or film.

The M.A. is a general humanistic degree that prepares students for a variety of situations, including teaching in private high schools or community colleges, or further graduate work. The Ph.D. is a more specialized degree. The Ph.D. in comparative literature can be combined with a minor in a professional field such as teaching English as a second language.

Only the faculty members and courses officially associated with the Comparative Literature program are listed here. The full range of faculty members and courses in related departments will also be available to comparative literature students according to their preparation.

Admission Requirements

Scores from the Graduate Record Examination (GRE) are not required for admission. They are required for most forms of financial aid, however, and therefore, applicants are encouraged to submit these scores. Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin*.

Students with a 3.00 junior-senior average and appropriate course backgrounds will be considered for admission. Most students who do graduate work in comparative literature hold a B.A. or M.A. degree in a national language and literature. Students completing degrees in such fields are welcome to apply — as are students in other humanistic fields, such as philosophy or history, if they have studied literature.

For admission to the M.A. program, students should be prepared to study at least one foreign literature in its own language; for admission to the Ph.D. program, students should be prepared to study at least two foreign literatures in their own language. Students are not admitted directly from the B.A. to the Ph.D. level but should complete the M.A. before being formally admitted to the Ph.D. program. Students are encouraged to plan a unified M.A./Ph.D. program if they take both degrees here; however, Ph.D. applications are welcomed from students holding or completing an M.A. elsewhere.

Master's Degree Requirements

Requirements for the M.A. in comparative literature include (1) C LIT 501; (2) 6 further credits in comparative literature courses; (3) 9 credits in one national literature and 6 credits in a second national literature; (4) proficiency in two foreign languages; (5) a written comprehensive examination based on a reading list; and (6) a 6-credit thesis.

On item (4), one of the foreign languages is to be at the level that permits thorough literary analysis of texts in that language; the second foreign language may be prepared at reading proficiency only.

Doctoral Degree Requirements

Requirements for the Ph.D. in comparative literature include (1) C LIT 501, 502, and 503 — with substitute courses if these have been used in the M.A. program; (2) at least 21 credits in either a concentration in three national literatures, or a concentration in a period, genre, theme, or area study; (3) an oral candidacy examination; (4) proficiency in three foreign languages; (4) a written comprehensive examination based on a reading list; and (5) a dissertation.

On item (4), two of the foreign languages are to be prepared at a level that permits thorough literary analysis of texts in those languages; the third foreign language may be prepared at reading proficiency only.

Other Relevant Information

Students pursuing a graduate degree in comparative literature have individualized programs of study within the requirements specified above. For example, one student may emphasize drama; another, the novel. One student may concentrate on earlier literatures; another, on modern. One student may be interested primarily in the European tradition; another, in the New World (or "Inter-American") literatures. In such a program, the relationship between student and adviser is important. Each graduate student works with faculty advisers (a general adviser and a thesis or dissertation adviser) familiar with comparative studies as a whole and with the student's particular area of interest.

Student Aid

Teaching assistantships in the Department of Comparative Literature, as well as in related language and literature departments, typically have been available to students taking comparative literature degrees. In 1987-88, comparative literature students held assistantships in Arabic, Chinese, English, French, German, Japanese, Polish, and Spanish, as well as in comparative literature courses. In addition to the fellowships, traineeships, graduate assistantships, and other forms of financial aid described in the STUDENT AID section of the *Graduate Bulletin*, the following awards typically have been available to graduate students in this program:

SAMUEL P. BAYARD AWARD — Available annually to a graduate student in comparative literature, selected by the graduate committee of the Department of Comparative Literature. Amount varies.

EDWIN ERLE SPARKS DISSERTATION FELLOWSHIP IN THE HUMANITIES — Available to a doctoral candidate in one of the following graduate programs: classics, comparative literature, English, French, German, history, linguistics, philosophy, religious studies, Slavic languages and literatures, Spanish, and speech communication; stipend $8,040 plus waiver of tuition. Apply to department before February 1.

EDWIN ERLE SPARKS FELLOWSHIPS IN THE HUMANITIES (8) — Available to beginning and continuing graduate students in one of the following graduate programs: classics, comparative literature, English, French, German, history, linguistics, philosophy, religious studies, Slavic languages and literatures, Spanish, and speech communication; stipend $6,740 plus waiver of tuition. Apply to department before February 1.

COMPARATIVE LITERATURE (C LIT)

400. SENIOR SEMINAR IN COMPARATIVE LITERATURE (3)
401. THE WESTERN LITERARY HERITAGE I (3)
402. THE WESTERN LITERARY HERITAGE II (3)
404. LITERARY MODES OF THE ORIENT (3) *Balaban*
405. INTER-AMERICAN LITERATURE (3) *Fitz*
406. WOMEN AND WORLD LITERATURE (3)
408. HEROIC LITERATURE (3) *Thigpen*
410. PROBLEMS IN TRANSLATION (3) *Fitz*
422. AFRICAN DRAMA (3) *Hale*
423. AFRICAN NOVEL (3) *Hale*
443. (GER 443) LITERARY RELATIONS OF GERMANY WITH ENGLAND AND AMERICA (3-9) *Kopp*
453. (COMM 453) NARRATIVE THEORY: FILM AND LITERATURE (3)
470. OLD MASTERS OF THE MODERN NOVEL (3) *Begnal*
480. THE INTERNATIONAL FOLKTALE (3) *Thigpen*
481. THEORY AND TECHNIQUES OF WORLD FOLKLORE (3)
486. TRAGEDY (3) *Lima*
487. COMEDY (3) *Knight*
488. (ENGL 488) MODERN CONTINENTAL DRAMA (3) *Grecco*
496. INDEPENDENT STUDIES (1-18)
497. SPECIAL TOPICS (1-9)
499. FOREIGN STUDY — COMPARATIVE LITERATURE (3-6)

501. COMPARATIVE METHOD IN LITERARY STUDIES (3) Bibliography, research methods, and studies in comparative literature. *Eckhardt and Fitz*

502. COMPARATIVE CRITICISM I: CLASSICAL TO NEOCLASSICAL (3) Issues in literary criticism from Plato and Aristotle to the mid-eighteenth century.

503. COMPARATIVE CRITICISM II: ROMANTIC TO CONTEMPORARY (3) Principles and theories of literary criticism from eighteenth- and nineteenth-century beginnings to twentieth-century expansion and application.

504. STUDIES IN LITERARY GENRES (3-6) The concept of genre and the evolution of genre theory; application to a specific genre, e.g., the lyric or the novel.

505. STUDIES IN LITERARY PERIODS AND MOVEMENTS (3-6) Comparative approaches to cohesive units within literary history, e.g., the Renaissance, the Enlightenment, Romanticism, Surrealism.

506. STUDIES IN LITERARY THEMES AND MOTIFS (3-6) Comparative approaches to recurrent literary themes and motifs; application to a specific example, e.g. literary Utopias or the Faust theme.

508. NORSE AND GAELIC SAGAS (3) Medieval Irish and Scandinavian prose tales surveyed and compared with respect to background, development, themes, and characteristics. *Bayard and Ebbinghaus*

510. THEORY AND PRACTICE OF TRANSLATION (3) Theories of translation and interpretation; importance of translation in literary transmission; application of theoretical concepts to individual translation projects. Prerequisites: 24 credits in a foreign language. *Fitz*

543. Literary Relations (3 per semester, maximum of 6) Mutual influences among specific literatures and cultures; for example, German-American, French-American, Inter-American, or East-West literary relations. *Kopp*

570. Forces in Contemporary Literature (3-6) Intellectual currents and experimental forms in contemporary world literature. *West*

580. Contemporary Literary Theory (3) Major issues in contemporary literary theory and their significance for criticism, with emphasis on continental European theorists and their influence.

590. Colloquium (1-3)

593. Anglo-American Folk Song (3) Survey of relevant literary and ethnological scholarship and field work, European and American, from the early sixteenth century to the present. *Bayard*

596. Individual Studies (1-9)

597. Special Topics (1-9)

599. Foreign Study — Comparative Literature (1-12) Graduate-level courses offered on comparative literary topics as part of a foreign-study experience approved by the program head. Prerequisites: 24 credits in the appropriate foreign language(s); 18 credits in literature or relevant related fields.

COMPUTER ENGINEERING (CMPEN)

TSE-YUN FENG, *Director of Computer Engineering Program*
108 Electrical Engineering West Building
814-863-1469

Degrees Conferred: Ph.D., M.S.

Senior Members of the Graduate Faculty
William S. Adams, Ph.D. (Penn State) *Professor of Electrical Engineering*
Lee D. Coraor, Ph.D. (Iowa) *Assistant Professor of Electrical Engineering*
Tse-yun Feng, Ph.D. (Michigan) *Professor of Computer Engineering*
Rangachar Kasturi, Ph.D. (Texas Tech) *Associate Professor of Electrical Engineering*
John J. Metzner, Ph.D. (New York) *Professor of Computer Engineering*

Associate Members of the Graduate Faculty
Chitaranjan Das, Ph.D. (S.W. Louisiana) *Assistant Professor of Computer Engineering*
Ahmed Elmagarmid, Ph.D. (Ohio State) *Assistant Professor of Computer Engineering*
Paul T. Hulina, Ph.D. (Penn State) *Associate Professor of Electrical Engineering*
Ali R. Hurson, Ph.D. (Central Florida) *Assistant Professor of Computer Engineering*
David L. Landis, Ph.D. (Penn State) *Assistant Professor of Electrical Engineering*
Woei Lin, Ph.D. (Texas at Austin) *Assistant Professor of Computer Engineering*
Simin H. Pakzad, Ph.D. (Oklahoma) *Assistant Professor of Computer Engineering*
Matthew J. Thazhuthaveetil, Ph.D. (Wisconsin at Madison) *Assistant Professor of Computer Engineering*

The major areas of graduate research are in VLSI, computer architecture, parallel/distributed processors and processing, multiprocessors, operating systems, databases, programming languages, computer communications and networks, pattern recognition and image processing, performance evaluation, reliability, and fault tolerance.

For information about areas of specialization, laboratory and research facilities, fellowships, assistantships, and other sources of financial assistance, write to the Computer Engineering Program, Department of Electrical Engineering, The Pennsylvania State University, University Park, PA 16802.

Admission Requirements
Scores from the Graduate Record Examination (GRE), or from a comparable substitute examination accepted by a graduate program and authorized by the dean of the Graduate School, are required for admission. At the discretion of a graduate program, a student may be admitted provisionally for graduate study in the program without these scores. Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin.*

Admission to M.S. Program: The entering student must hold a bachelor's degree in computer engineering from an accredited institution, or its equivalent, and should have obtained at least a 3.00/4.00 undergraduate grade-point average.

Admission to Ph.D. Program: Students entering directly from a B.S. program must have a Bachelor of Science degree in computer engineering from an accredited institution or its equivalent, and they must show promise of superior performance in a doctoral program. Students entering with an M.S. degree should have obtained that degree in computer engineering or its equivalent.

Master's Degree Requirements

The Master of Science requirements include the general requirements of the Graduate School as listed under Master's Degree Requirements.

Specific Course Requirements: (1) Thesis option — 24 course credits, 6 thesis credits, and a satisfactory thesis; (2) Nonthesis option — 32 course credits, including a selection of three core and other 500-level courses and a scholarly report.

Doctoral Degree Requirements

The Doctor of Philosophy requirements include the general requirements of the Graduate School as listed under Doctoral Degree Requirements.

To qualify for a Ph.D. degree, each student shall take a minimum of 48 nonthesis course credits beyond the baccalaureate degree, with at least 27 at the 500 level. No more than 9 of the 48 course credits should be individual study (CMPEN 496 or CMPEN 596). At least 9 credits must be selected from a list of approved courses offered by other departments. In addition, the student is required to pass the Ph.D. candidacy examination before the end of the third regular semester after entering the program, the communication and language requirements, and then the comprehensive examination after completion of a major portion of the course work.

Other Relevant Information

Continuous registration is required for all graduate students until the thesis or engineering report is approved.

Student Aid

Graduate assistantships available to students in this program and other forms of student aid are described in the STUDENT AID section of the *Graduate Bulletin*.

COMPUTER ENGINEERING (CMPEN)

415. (CMPSC 415) Computer Systems Architecture (3)
447. Digital Integrated Circuits (3)
449. VLSI Digital Circuits (3)
458. Data Communication (3)
470. Electronic Analog Computers (3)
471. Logical Design of Digital Systems (3)
472. Mini/Micro Computers (3)
473. Mini/Micro Computer Laboratory (3)
475. Introduction to Hybrid Computation (3)
478. Applied Programming Languages (3)
494. Senior Thesis (1-9)
496. Independent Studies (1-18)
497. Special Topics (1-9)

501. Electronic Analog Computers (3) Advanced techniques of analog computation and simulation; machine and problem errors; nonlinear differential equations. Prerequisite: CMPEN 470.

511. Switching and Sequential Machine Theory (3) Advanced treatment of switching and machine theory, minimization of machines, state assignment, hazard analysis. Prerequisite: CMPEN 471.

512. Digital System Design (3) Complete digital system design, including specification, internal organization, and realization. Discussion of interaction among digital systems and subsystems. Prerequisite: CMPEN 472.

521. Integrated Circuit and System Design (3) Engineering design of large-scale integrated circuits, systems, and applications; study of advanced design techniques, architectures, and CAD methodologies. Prerequisite: CMPEN 449.

522. Digital Integrated Circuit Evaluation Laboratory (3) Logic performance characterization, functional testing, fault analysis, and demonstration of student-designed, custom-integrated circuits. Prerequisite: CMPEN 577.

531. Parallel Processors and Processing (3) Parallel processor organization; basic algorithms suitable for such systems; parallel sorting and interconnection networks; applications and discussion of specific processors. Prerequisite: CMPEN 415 or CMPSC 415.

532. Multiprocessor Architecture (3) Fundamental structures of multiprocessors; interprocess communications; system deadlocks and protection, scheduling strategies, and parallel algorithms; example multiprocessor systems. Prerequisites: CMPEN 415 or CMPSC 415; CMPEN 478.

533. Unconventional Machine Architecture (3) Shortcomings of the Von-Neumann model; resolution of those shortcomings; architectural effects of these solutions; effects of technological advances. Prerequisite: CMPEN 415 or CMPSC 415.

536. Fault Tolerant Systems (3) Attributes of fault-tolerant systems and their definitions; reliability and availability techniques; maintainability and testing techniques; practice of reliable system design. Prerequisites: CMPEN 415, 471.

561. Data Engineering (3) Data models and relational database design; database integrity and concurrency control; distributed database design and concurrency control; query optimization.

594. Research Topics (1 per semester) Supervision of individual research projects leading to M.S. papers. Written and oral reports are required. Course may be repeated. (An "R" grade may be given.)

596. Individual Studies (1-9)

597. Special Topics (1-9)

COMPUTER SCIENCE (CMPSC)

JOSEPH M. LAMBERT, *Head of the Department*
333 Whitmore Laboratory
814-865-9505

Degrees Conferred: Ph.D., M.S.

Senior Members of the Graduate Faculty
Jesse Barlow, Ph.D. (Northwestern) *Associate Professor of Computer Science*
Jonathan Goldstine, Ph.D. (California-Berkeley) *Associate Professor of Computer Science*
Mary Jane Irwin, Ph.D. (Illinois) *Associate Professor of Computer Science*
Donald T. Laird, Ph.D. (Penn State) *Associate Professor of Computer Science*
Webb Millller, Ph.D. (Washington) *Professor of Computer Science*
L. Ridgway Scott, Ph.D. (MIT) *Professor of Computer Science and Mathematics*

Associate Members of the Graduate Faculty
Piotr Berman, Ph.D. (MIT) *Assistant Professor of Computer Science*
Thang Bui, Ph.D. (MIT) *Assistant Professor of Computer Science*
Martin Fürer, Dr.Sc.Math. (ETH-Zürich) *Associate Professor of Computer Science*
Suchitra Gupta, Ph.D. (SUNY-Stony Brook) *Assistant Professor of Computer Science*
Gerald G. Johnson, Jr., Ph.D. (Penn State) *Associate Professor of Computer Science*
Krishna Kant, Ph.D. (Texas-Dallas) *Assistant Professor of Computer Science*
Joseph M. Lambert, Ph.D. (Purdue) *Associate Professor of Computer Science*
Sing-Ling Lee, Ph.D. (Texas-Dallas) *Assistant Professor of Computer Science*
Anthony Maida, Ph.D. (SUNY-Buffalo) *Assistant Professor of Computer Science*
K. T. Narayana, Ph.D. (Queen's-Belfast) *Assistant Professor of Computer Science*
Narayanan Natarajan, Ph.D. (Bombay) *Assistant Professor of Computer Science*
Robert M. Owens, Ph.D. (Penn State) *Assistant Professor of Computer Science*
Ian Parberry, Ph.D. (Warwick) *Assistant Professor of Computer Science*
Panayote Pardalos, Ph.D. (Minnesota) *Assistant Professor of Computer Science*
Alex Pothen, Ph.D. (Cornell) *Assistant Professor of Computer Science*
S. Purushothaman, Ph.D. (Utah) *Assistant Professor of Computer Science*
Paolo Roberti, Ph.D. (California-Los Angeles) *Assistant Professor of Computer Science*
Georg Schnitger (Bielefeld, W. Germany) *Assistant Professor of Computer Science*
R. Shyamasundar, Ph.D. (Indian Institute of Science) *Associate Professor of Computer Science*

The department offers courses and is prepared to direct research in a variety of subfields of computer science, including artificial intelligence and cognitive science; computer systems; numerical analysis and optimization; programming methodology; theory and design of VLSI systems and architectures; theory of computation; and analysis of algorithms. Research and instruction are supported by extensive computing facilities in the University's Computation Center and by the Computer Systems Laboratory operated by the department.

Admission Requirements

Scores from the general and subject test (computer science) portions of the Graduate Record Examination (GRE) are required for admission. At the discretion of a graduate program, a student may be admitted provisionally for graduate study in a program without these scores. Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin*.

Admission to the M.S. program without deficiency requires that an applicant should have completed courses in computer science at the advanced undergraduate level from the areas of data structures and algorithms, an introductory course in operating systems, computer architecture, theory of automata, formal languages and computability, numerical analysis, and matrix algebra. In addition, the student is expected to have mathematics training which includes calculus, linear algebra, and some discrete mathematics.

Students with at least a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students.

Master's Degree Requirements

The M.S. candidate must satisfactorily complete the requirements of the Graduate School. In addition, at least 12 of the required 500-level credits shall be regular courses in the Department of Computer Science meeting certain distribution requirements described in the departmental brochure "The Graduate Program in Computer Science at Penn State." The nonthesis option is available for the M.S. degree. The candidate also may be required to demonstrate proficiency in the design and implementation of computer programs or computer-related systems, or both.

Doctoral Degree Requirements

The Ph.D. degree is primarily a research degree and is conferred on the basis of original work and high academic achievement in computer science. In order to be accepted as a candidate, the student must pass a written candidacy examination. The communication and foreign language requirement for the Ph.D. degree may be satisfied by a proficiency in one foreign language (French, German, or Russian). These and additional requirements are detailed in the departmental brochure cited above.

Other Relevant Information

Students in this program may elect the dual-title degree program option in Operations Research for the Ph.D. and M.S. degrees (see p. 326).

Student Aid

Graduate assistantships available to students in this program and other forms of student aid are described in the STUDENT AID section of the *Graduate Bulletin*.

COMPUTER SCIENCE (CMPSC)

403. Advanced Programming for Nonmajors (3)
408. (CHEM 408) Computer Applications in Chemistry (3)
412. Operating Systems (3)
413. Projects in Computer Systems (3)
415. (CMPEN 415) Computer Systems Architecture (3)
416. Software Design Methods (3)
418. Computer Graphics (3)
421. Introduction to Compiler Construction (3)
430. Combinatorics and Graph Theory (3)
435. Data Structures and Algorithms (4)
436. Programming Language Concepts (4)
441. Introduction to Database Management Systems (3)
442. Advanced Programming and Job Control Language (3)
444. Systems and Program Design in EDP (3)

453. (MATH 453) Numerical Computations (3)
454. (MATH 454) Matrix Computations (3)
467. (MATH 467) Algorithms in Number Theory (3)
468. Theory of Automata, Languages, and Computability (3)
481. Introduction to Artificial Intelligence I (3)
482. Introduction to Artificial Intelligence II (3)
491. Computer Projects (1-12)
496. Independent Studies (1-18)
497. Special Topics (1-9)

511. Operating Systems Design (4) Concurrent programming; design of I/O subsystem, memory management, and user interface; kernel design; deadlocks, protection and security; case studies. Prerequisites: CMPSC 211; an introductory course in operating systems.

512. Computer Systems Performance Evaluation (3) Theory and practice of computer system performance evaluation; measurement, simulation, and analytical techniques with strong emphasis on analytical modeling. Prerequisities: CMPSC 511, MATH 414.

513. Computer Networks and Distributed Systems (3) Protocol hierarchies; routing and flow control algorithms; distributed operating systems; communication and synchronization mechanisms; resource allocation problems. Prerequisite: CMPSC 511.

517. VLSI Computer-Aided Design Tools (3) VLSI circuit design tools: placement, routing, extraction, design rule checking, graphic editors, simulation, verification, minimization, silicon compilation, test pattern generation. Prerequisite: CMPSC 576 or extensive programming experience.

520. Science of Computer Programming (4) Weakest preconditions, nondeterminism, terminating constructs, formal derivation of some often used algorithms, correctness of programs, formal specification of large systems.

521. Compiler Construction (4) Design and implementation of compilers. Prerequisites: CMPSC 435 or 534.

522. Semantics of Programming Languages (3) Operational, axiomatic, and denotation semantics of programming languages; fixpoint theory of computation, verification of recursive programs; goto statements and continuations. Prerequisite: CMPSC 520.

524. Design and Specification of Distributed Systems (3) Specification of distributed systems; safety and liveness properties; temporal logics; trace semantics; logic programs; specification and verification of distributed algorithms. Prerequisite: CMPSC 520.

534. Algorithm Design and Analysis (4) An introduction to algorithmic design and analysis. Prerequisite: graduate standing in computer science or CMPSC 435. Concurrent: CMPSC 468.

535. Theory of Graphs and Networks (3) Theory and applications of graphs, including structure of graphs, network analysis, and algorithms for computer solution of graph-theoretic problems. Prerequisites: CMPSC 430, 534.

536. Numerical Optimization Techniques (3) Unconstrained and constrained optimization methods, linear and quadratic programming, software issues, ellipsoid and Karmarkar's algorithm, global optimization, parallelism in optimization. Prerequisite: CMPSC 453 or 454.

538. Parallel Algorithms (3) Computational aspects of VLSI: synthesis/analysis of efficient parallel and distributed algorithms; computational structures; models of parallel computers and their interrelationships. Prerequisite: CMPSC 435 or 468 or 534.

539. Complexity of Combinatorial Problems (3) NP-completeness theory; approximation and heuristic techniques; discrete scheduling; additional complexity classes. Prerequisite: CMPSC 430 or 534.

541. Database Management Systems (4) Computer system organization for the management of data, data models, and implementation; primary and secondary key retrieval algorithms. Prerequisites: CMPSC 435 or 534.

542. Information Processing Systems (3) Data structure and data processing; information retrieval systems. Prerequisite: CMPSC 541.

550. (MATH 550) Numerical Algebra (3) Zeros of polynomials; iterative solution of linear and nonlinear systems; sparse matrix techniques; eigenvalues and eigenvectors. Prerequisite: CMPSC (MATH) 454 or MATH 441.

551. (MATH 551) Numerical Solution of Ordinary Differential Equations (3) Methods for initial value and boundary value problems. Stability and convergence analysis, automatic error control, and stiff systems. Prerequisites: CMPSC (MATH) 453, MATH 411.

552. (MATH 552) Numerical Solution of Partial Differential Equations (3) Methods of parabolic, hyperbolic, and elliptic partial differential equations; finite difference and variational methods; splines, finite elements. Prerequisites: CMPSC (MATH) 453 or 454; MATH 405.

553. (MATH 553) Introduction to Approximation Theory (3) Interpolation; remainder theory; approximation of functions; error analysis; orthogonal polynomials; approximation of linear functionals; functional analysis applied to numerical analysis. Prerequisites: MATH 401; 3 credits in computer science.

556. (MATH 556) Finite Element Methods (3) Variational formulations of partial differential equations; algorithms and errors for finite element approximations; isoparametric elements; nonlinear partial differential equations. Prerequisite: CMPSC 454.

559. Computability and Recursive Functions (3) Mathematical treatment of computability, recursive functions, Turing machines, unsolvable problems, recursive and recursively enumerable sets. Prerequisite: CMPSC 468.

561. Sequential and Parallel Complexity Theory (3) Models of sequential and parallel computers; relationships between complexity measures; simulations and universality; resource-bounded hierarchies; lower-bound techniques. Prerequisite: CMPSC 468.

562. Probabilistic Algorithms (3) Design and analysis of probabilistic algorithms, reliability problems, probabilistic complexity classes, lower bounds. Prerequisite: CMPSC 534.

568-569. Theory of Formal Languages and Automata (3 each) Generation and recognition of formal languages, grammars, Chomsky's hierarchy of languages, closure properties, characterization by automata, algebraic properties, complexity classification. Prerequisite: CMPSC 468.

574. Contemporary Computer Architectures (3) Contemporary computer organizations and operations; parallel systems: pipelines, array, multiprocessors; shared memory and message passing architectures; data flow architectures. Prerequisites: CMPSC 415 and a course in operating systems.

575. Architecture of Arithmetic Processors (3) Algorithms and techniques for designing arithmetic processors; conventional algorithms and processor design; high-speed algorithms and resulting architectural structures. Prerequisite: CMPSC 415.

576. Digital Integrated Systems Design (3) Introduction to VLSI design and fabrication, design methodologies and CAD tools, system case studies. Prerequisite: CMPSC 415.

577. VLSI Systems Design (3) Design of VLSI circuits, systems, and CAD tools; study of advanced VLSI architectures, CAD tools for design, and evolving design techniques. Prerequisite: CMPSC 576.

579. (MATH 579) Special Topics in Numerical Analysis (2-12)

581. Machine Intelligence and Heuristic Programming (3) Methods for making machines behave intelligently; problem solving, theorem proving, game playing, question answering, learning, induction; specialized languages and data structures. Prerequisite: CMPSC 481.

587. Introduction to Computational Linguistics (3) An introduction to the computational approach to linguistics, covering natural language parsing, meaning representation and inference, and natural language generation. Prerequisite: CMPSC 481.

590. Colloquium (1-3)

596. Individual Studies (1-9)

597. Special Topics (1-9)

COUNSELING PSYCHOLOGY (CNPSY)

EDWIN L. HERR, *Head of the Division of Counseling and Educational Psychology and Career Studies*
327 Cedar Building
814-865-6643

Degrees Conferred: Ph.D.

Senior Members of the Graduate Faculty
Stanley B. Baker, Ph.D. (SUNY) *Professor of Education*
Bernard G. Guerney, Jr., Ph.D. (Penn State) *Professor of Human Development and Counseling Psychology*
Louise F. Guerney, Ph.D. (Penn State) *Associate Professor of Human Development and Counseling Psychology*
Edwin L. Herr, Ed.D. (Columbia) *Professor of Education*
Donald B. Keat II, Ph.D. (Temple) *Professor of Education*
James W. Kelz, Ph.D. (Penn State) *Professor of Education*
Robert B. Slaney, Ph.D. (Ohio State) *Associate Professor of Counseling Psychology*

Associate Members of the Graduate Faculty
Dennis E. Heitzmann, Ph.D. (Texas) *Affiliate Assistant Professor of Counseling Psychology*
Elaine I. Johnson, Ph.D. (Iowa State) *Assistant Professor of Counseling Psychology*
Jack R. Rayman, Ph.D. (Iowa) *Affiliate Associate Professor of Education*

The Ph.D. in Counseling Psychology is Fully Approved by the American Psychological Association and approved by the Pennsylvania Board of Psychologist Examiners. This degree program is designed to train counseling psychologists in the scientist-practitioner model. Graduates of this program are automatically entitled to sit for the psychology licensure examination in Pennsylvania and in most other states. Requirements vary from state to state so students desiring licensure in other states must determine the requirements of the state in which they intend to practice, although graduation from an A.P.A.-approved doctoral training program in counseling psychology is ordinarily sufficient to qualify to sit for a state licensure examination as a psychologist.

Admission Requirements

Scores from the Graduate Record Examination (GRE) are required for admission. At the discretion of a graduate program, a student may be admitted provisionally for graduate study in a program without these scores. Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin*.

All candidates for the Ph.D. in Counseling Psychology must present a master's degree program, the content of which is relevant to counseling psychology (e.g., rehabilitation counseling, counselor education, clinical or general psychology). Doctoral candidates should present a 3.33 average in all graduate study completed.

Degree Requirements

In addition to academic competence, all candidates are expected to exhibit effectiveness in interpersonal relations and in both written and oral communication. They also must evidence support of professional counseling activities and organizations.

Ph.D. students in Counseling Psychology must satisfy degree requirements in statistics and research design, general psychology foundations, and a counseling specialty area. In addition, students participate in extensive practicum, clinic team, and internship experiences under supervision. As part of the requirements for the Ph.D., all students must spend a minimum of nine months full time or two years part time in an internship in a counseling center or other facility meeting criteria set by the American Psychological Association.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by a comprehensive knowledge of one foreign language and courses from other designated areas, or by options from designated areas selected to include competence in statistics, research design, computer application, or measurement.

Student Aid

Graduate assistantships available to students in this program and other forms of student aid are described in the STUDENT AID section of the *Graduate Bulletin*.

COUNSELING PSYCHOLOGY (CNPSY)

502. Advanced Counseling Theory and Method (3) Assessment, intervention, and evaluation procedures for counseling problems frequently encountered in school, college, and rehabilitation settings. Prerequisite: CN ED 501.

555. Career Counseling (3) The examination of historical, legislative, and current models of career counseling and the development of pertinent individual and group techniques. Prerequisite: CN ED 505.

591. Seminar in Counseling: History and Trends (1) Discussion of the history of guidance and counseling, emphasizing how the past has shaped the present and portends the future. Prerequisites: 9 credits in counselor education.

592. Seminar in Counseling: Legal and Ethical Concerns (1-2) Study and discussion of legal, ethical, and professional concerns of counselors; privileged communication, data banks, and privacy invasion. Prerequisites: 9 credits in counselor education.

593. Seminar in Counseling: Philosophy (1) Study and discussion of such philosophical foundations of counseling as phenomenology, idealism, realism, existentialism, daseinanalytic, theological, and other contemporary thoughts. Prerequisites: 9 credits in counselor education.

594. Research in Counseling (2-6) The design, implementation, and evaluation of counseling research projects. Prerequisites: CN ED 425, 501, 505. Prerequisite or concurrent: EDPSY 506.

595A. Counseling Psychology Practicum (1-6) Practice in the application of counseling psychology principles and methods to cases counseled under supervision; case conferences. Prerequisites: CN ED 425, 505, 506.

596. Individual Studies (1-9)

597. Special Topics (1-9)

602. Supervised Experience in College Teaching (1-3 per semester, maximum of 6)

COUNSELOR EDUCATION (CN ED)

EDWIN L. HERR, *Head of the Division of Counseling and Educational Psychology*
327 Cedar Building
814-865-3427

Degrees Conferred: D.Ed., M.S., M.Ed.

Senior Members of the Graduate Faculty
Stanley B. Baker, Ph.D. (SUNY) *Associate Professor of Education*
Edwin L. Herr, Ed.D. (Columbia) *Professor of Education*
Donald B. Keat II, Ph.D. (Temple) *Professor of Education*
James W. Kelz, Ph.D. (Penn State) *Professor of Education*
Thomas E. Long, D.Ed. (Penn State) *Professor of Vocational Education and Counselor Education*
John D. Swisher, Ph.D. (Ohio State) *Professor of Education*

Associate Members of the Graduate Faculty
Harold E. Cheatham, Ph.D. (Case Western Reserve) *Associate Professor of Education*
Jack R. Rayman, Ph.D. (Iowa) *Affiliate Associate Professor of Education*
M. Lee Upcraft, Ph.D. (Michigan State) *Affiliate Associate Professor of Education*
Alex Ursprung, Ph.D. (Syracuse) *Assistant Professor of Education*
Eric R. White, Ed.D. (Pennsylvania) *Affiliate Assistant Professor of Education*

Professional preparation is offered at the master's level for school counselors (elementary and secondary), college counselors or persons entering college student personnel services, and rehabilitation counselors. Credits required by different master's options vary from 32 to 54. The doctoral program prepares candidates for positions of responsibility and leadership in these same areas, as well as in the education of counselors and the management and supervision of counseling services.

Admission Requirements

Scores from the Graduate Record Examination (GRE) are required for admission. At the discretion of a graduate program, a student may be admitted provisionally for graduate study in a program without these scores. Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin*.

All candidates for graduate degrees in Counselor Education must present for admission at least 27 undergraduate credits of 3.00 or better, distributed among at least three of the following areas: economics, education, psychology, sociology, and physiology or anatomy.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests. Doctoral candidates should present at least a 3.33 average in all graduate study completed.

Degree Requirements

All candidates are expected to exhibit, in addition to academic competence, effectiveness in interpersonal relations and in both written and oral communication. They also must evidence support of professional counseling activities and organizations. All degree options require students to participate in extensive practicum or field work experience under supervision.

D.Ed. students in Counselor Education must satisfy degree requirements in empirical foundations, career guidance; administration, planning, and management in service delivery settings; and a minor field of study.

Student Aid

Graduate assistantships available to students in this program and other forms of student aid are described in the STUDENT AID section of the *Graduate Bulletin*.

COUNSELOR EDUCATION (CN ED)

403. Foundations of Guidance and Counseling Processes (3)
404. Group Procedures in Guidance and Counseling (3)
407. Introduction to Vocational Rehabilitation in Employee Counseling (3)
408. Introduction to Vocational Rehabilitation (3)
409. Medical Information for Counselors (3)
410. Rehabilitation of the Mentally Ill (3)
412. Rehabilitation Facilities and Services of Pennsylvania (3)
413. Rehabilitation Case Recording and Management (3)
414. Rehabilitation Facilities and Services in Industrial Settings (3)
415. Counseling Adults (3)
417. (VOCED 417) Career Education: Origins, Theory, Implementation (3)
425. The Use of Tests in Counseling (3)
470. Workshop in Studies in Counselor Education (1-6)
490. Seminar on Rehabilitation Counseling in Employee Assistance Programs (3)
495A. Field Work in Vocational Habilitation (12-18)
496. Independent Studies (1-18)
497. Special Topics (1-9)

501. Counseling Theory and Method (3) Survey of psychodynamic, rational, and behavioral approaches to counseling individuals, with particular emphasis on problems of choice.

503. Guidance Services in Elementary Education (3) Guidance services to elementary school students; guidance opportunities for elementary teachers and principals.

504. Guidance Services in Secondary Education (3) Nature and scope of guidance in secondary schools — services, models, and strategies; the counselor as an agent of change.

505. Foundations of Counseling Information (3) Accelerating change in economic, psychological, social, educational influences upon counselees. Utilization of information systems in effecting counselee change.

506. Individual Analysis and Counseling Procedures (3) Collection and use of data basic to the counselor's understanding of individuals; the counseling interview and techniques other than testing. Prerequisite: CN ED 501.

508. Organization and Administration of Guidance Programs (3) Principles, organization, personnel, functions, integration with school programs, evaluation.

509. Contributions of Professional Personnel to Vocational Rehabilitation (3) Contributions of medical, social, psychological, and other specialists through the team approach; professional ethics, medical problems. Prerequisite: CN ED 408.

551. Student Personnel Services (2-3) Student personnel services in higher education; organization of student advisory programs; use of personnel data; cocurricular activities; student welfare.

553. Student Personnel Services Programming (2-3) Formulation of policies as guides to the student personnel service programs; integration of program elements; research; current problems and trends. Prerequisite: CN ED 551.

554. Cross-Cultural Counseling (3) Examines theory, research, and models of counseling relationships between counselors and clients of different racial and sociocultural backgrounds. Prerequisites: CN ED 501, 506.

560. Psychosocial Aspects of Disability (3) Psychological models of reaction to disability and social consequences in adulthood; generalizations to other life crises; implications for counselor interventions. Prerequisites: 9 credits in counselor education or related area.

561. Job Development and Placement for the Handicapped (3) Assessing client readiness for work; job-seeking skills training; job placement strategies; modifications to the worksite; methods for employer development. Prerequisites: CN ED 408, 425.

595A. Counseling Practicum (1-6) Practice in the application of guidance principles and methods to cases counseled under supervision; case conferences; seminar in guidance techniques. Prerequisites: CN ED 425, 505, 506.

595B. Supervised Practicum in Rehabilitation Counseling (1-6) Application of principles and techniques of rehabilitation counseling to cases involving handicapped individuals. Prerequisites: CN ED 408, 425, 505, 506.

595C. Professional Experience in Rehabilitation Counseling (1-15) Supervised internship, with responsibility for a regular case load. Prerequisites: CN ED 409, 595B.

595D. Supervision of Counselors (3-9) Practical experience in supervising and evaluating work of counselors. Prerequisite: CN ED 595A or 595B.

595E. Elementary School Counseling Internship and Seminar (1-2 per semester, maximum of 6) Off-campus, supervised internships in elementary school settings with supplementary related topics, discussion, and skills training in on-campus seminars. Prerequisite or concurrent: CN ED 503.

595F. Secondary School Counseling Internship and Seminar (1-2 per semester, maximum of 6) Off-campus, supervised internships in secondary school settings with supplementary related topics, discussion, and skills training seminars. Prerequisite or concurrent: CN ED 504.

595G. Student Personnel Internship and Integrative Seminar (1-6 per semester, maximum of 9) Off-campus, supervised internships in postsecondary-related college-student personnel settings with pertinent topics, discussion; skills training seminars on campus. Prerequisite or concurrent: CN ED 551.

596. Individual Studies (1-9)

597. Special Topics (1-9)

602. Supervised Experience in College Teaching (1-3 per semester, maximum of 6)

CURRICULUM AND INSTRUCTION (C I)

ROBERT L. SHRIGLEY, *Coordinator for Graduate Studies in Curriculum and Instruction*
168 Chambers Building
814-865-5433

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Senior Members of the Graduate Faculty
Eunice N. Askov, Ph.D. (Wisconsin) *Professor of Education*
Paul E. Bell, D.Ed. (Oregon) *Associate Professor of Education*
Carol A. Cartwright, Ph.D. (Pittsburgh) *Professor of Education*
Mary M. Dupuis, Ph.D. (Penn State) *Professor of Education*
Victor L. Dupuis, Ph.D. (Purdue) *Professor of Education*
Francis M. Dwyer, Jr., D.Ed. (Penn State) *Professor of Education*
Michael J. Hannafin, Ph.D. (Arizona State) *Associate Professor of Education*
Henry J. Hermanowicz, Ed.D. (Columbia) *Professor of Education*
James E. Johnson, Ph.D. (Wayne State) *Associate Professor of Education*
Jane M. Madsen, Ed.D. (Arizona State) *Associate Professor of Education*
Murry R. Nelson, Ph.D. (Stanford) *Professor of Education*
Robert F. Nicely, Jr., Ph.D. (Pittsburgh) *Professor of Education*
Joseph O. Prewitt-Diáz, Ph.D. (Connecticut) *Associate Professor of Education*
Peter Anthony Rubba, Ed.D. (Indiana) *Associate Professor of Education*
Edmund C. Short, Ed.D. (Columbia) *Associate Professor of Education*
Robert L. Shrigley, D.Ed. (Penn State) *Professor of Education*
Cecil R. Trueblood, D.Ed. (Penn State) *Professor of Education*
Paul W. Welliver, Ph.D. (Penn State) *Professor of Education*

Associate Members of the Graduate Faculty
Glendon W. Blume, Ph.D. (Wisconsin) *Assistant Professor of Education*
Frances E. Fairchild, D.Ed. (Missouri) *Associate Professor of Education*
David Alan Gallup, Ed.D. (Penn State) *Assistant Professor of Education*
M. Kathleen Heid, Ph.D. (Maryland) *Assistant Professor of Education*
James H. Hogg, D.Ed. (Penn State) *Associate Professor of Education*
Donald W. Johnson, Ed.D. (Colorado) *Professor of Education*
John A. Jorgenson, Ed.D. (Temple) *Assistant Professor of Education*
Joyce Lee, D.Ed. (Penn State) *Assistant Professor of Education*
James Levin, Ph.D. (Penn State) *Affiliate Assistant Professor of Education*
James F. Nolan, Ph.D. (Penn State) *Assistant Professor of Education*
Martin W. Sharp, Jr., D.Ed. (Penn State) *Assistant Professor of Education*
Barbara J. Smith, D.Ed. (Penn State) *Associate Librarian; Associate Professor of Education*
Lourdes Diaz Soto, Ph.D. (Penn State) *Assistant Professor of Education*
Elizabeth B. Swadener, Ph.D. (Wisconsin) *Assistant Professor of Education*
Brenda S. Townsend, Ph.D. (Penn State) *Assistant Professor of Education*

This program provides advanced professional preparation in the special areas of supervision and curriculum development, bilingual education, early childhood education, elementary education, instructional systems, language arts and reading, science education, social studies education, and mathematics education.

The M.S. and M.Ed. program are also available at Penn State Great Valley.

Admission Requirements
Scores from the Miller Analogies Test (MAT) are required for admission. At the discretion of a graduate program, a student may be admitted provisionally for graduate study in a program without these scores. Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin*.

Students with appropriate course and professional backgrounds will be considered for admission, subject to the limitation of program facilities. For admission to the professional degree programs leading to the M.Ed. and D.Ed., teaching or equivalent experience and at least 18 credits in education are recommended.

Master's Degree Requirements
M.Ed. and M.S. candidates are expected to complete the core: EDPSY 421, C I 400, and C I 550, or the equivalent.

Candidates for the M.Ed. degree with a minor in Curriculum and Instruction must take a minimum of 6 course credits approved in advance.

Doctoral Degree Requirements

The completion of a core of competencies in curriculum, instruction, and supervision is expected of Ph.D. and D.Ed. candidates.

To meet residency requirements, the Ph.D. candidate must spend at least two consecutive semesters enrolled as a full-time student at the University Park Campus. The D.Ed. candidate must spend at least two consecutive sessions (e.g., semester, summer session) enrolled as a full-time student at the University Park Campus. The communication and foreign language requirement for the Ph.D. degree may be satisfied by completing two of the following options: foreign language, statistics, computer science and technology, linguistics, ethnography, demography, historiography, or technical writing.

Candidates for the D.Ed. degree with a minor in Curriculum and Instruction must take a minimum of 15 course credits approved in advance by the professor in charge of graduate programs in Curriculum and Instruction.

Student Aid

Graduate assistantships available to students in this program and other forms of student aid are described in the STUDENT AID section of the *Graduate Bulletin*.

CURRICULUM AND INSTRUCTION (C I)

400. Introduction to Research Literature (3)
408. Methods of Teaching Basic Skills (4-6)
409. Instructional Design, Development, and Evaluation (4)
411W. Secondary Teaching I (3)
412W. Secondary Teaching II (3)
494H. Research Techniques in Curriculum and Instruction (1-3)
495A. Clinical Application of Instruction — Early Childhood Education (3 per semester, maximum of 6)
495B. Clinical Application of Instruction — Elementary and Kindergarten Education (3-6)
495C. Clinical Application of Instruction — Secondary Education (3-6)
495D. Practicum in Student Teaching — Elementary and Kindergarten Education (12)
495E. Practicum in Student Teaching — Secondary Education (15)
495F. Professional Development Practicum (3)
496. Independent Studies (1-18)
497. Special Topics (1-9)

550. Overview of Contemporary School Curriculum (3) Current school programs and options and their impact on pupils; problems in introducing new content into the curriculum. Prerequisites: 12 credits in education and psychology or teaching experience.

590. Colloquium (1-3)

595. Internship in Curriculum, Supervision, or Instruction (1-6) Internship in schools or other educational settings under supervision of graduate faculty in the student's area of specialization. Prerequisites: approval by program head; at least 15 graduate-level credits in education.

596. Individual Studies (1-9)

597. Special Topics (1-9)

602. Supervised Experience in College Teaching (1-3 per semester, maximum of 6)

CURRICULUM AND SUPERVISION (C & S)

401. Measurement and Evaluation of Instruction, K-12 (3)
405. Strategies in Classroom Management (3)
451. Instruction in Early Childhood Education Derived from Developmental Theories (4)
452. Analysis of Model Early Childhood Education Programs (3)
453. Parent Involvement in Home, Center, and Classroom Instruction, N-12 (3)

454. (I F S 454) Development and Administration of Child Service Programs (3)
470. Workshop in Selected Studies in Curriculum (1-6)
471. Workshop in Selected Studies in Supervision (1-6)
479. The Young Child's Play as Educative Processes I (4)
496. Independent Studies (1-18)
497. Special Topics (1-9)

551. Curriculum Design: Theory and Practice (3) The analysis and use of the foundations which underlie models of curriculum design. Prerequisite: C I 550.

553. Issues and Trends in School Programs (3 per semester, maximum of 6) In-depth study of issues and trends in designing comprehensive programs at either the elementary, middle, or high school level. Prerequisites: 12 graduate credits in education.

554. Long-Range Planning for School Programs (3) Strategies and techniques for conducting long-range planning of educational programs. Prerequisite: C & S 551 or C I 550.

555. Development of Teacher Education Programs (3) Study of the components and design of teacher education programs within the constraints of institutional, professional, and legal contexts. Prerequisite: C & S 551 or C I 550.

557. Seminar in Curriculum Research (3) Analysis of particular curriculum studies, methods and paradigms, and the general status of current research in the general curriculum field. Prerequisites: C I 400, 550.

558. Standard Works in Curriculum and Instruction (3) Study of significant empirical, historical, evaluative, philosophical, and critical works having an impact on curriculum and instruction practice. Prerequisite: C & S 551.

560. Principles of Instructional Supervision (3) Social and institutional settings for instructional supervision; functions, activities, and practices of supervision; supervisory case studies. Prerequisites: teaching or school administrative experience; 18 credits in education, at least 5 of which are methods of teaching.

561. Methods of Clinical Supervision (3) A course in supervision for master teachers, department heads, and college teachers with supervisory responsibilities. Prerequisites: teaching experience; 18 credits in education, including at least 5 in methods of teaching.

562. Systematic Observation of Instruction (3) Construction and use of valid and reliable systematic observation systems used as a basis for classroom observation of instruction. Prerequisites: student teaching or teaching experience; C & S 560 or 561.

563. Designing Staff Development Programs (3) Designing, implementing, and evaluating effective staff development programs for personnel in educational settings. Prerequisite: C & S 560.

572. Issues and Trends in Early Childhood Education (3 per semester, maximum of 9) Research, experimental programs, and emerging trends in early childhood education; relationships between educational experiences and later intellectual and emotional development. Prerequisites: C & S 452, EDPSY 400.

589. The Young Child's Play as Educative Processes II (4) Child's play and gaming processes as assessment and diagnosis for readiness in early childhood education practicum with children. Prerequisite: C & S 479.

596. Individual Studies (1-9)

597. Special Topics (1-9)

INSTRUCTIONAL SYSTEMS (INSYS)

411. Orientation to Instructional Systems (2-3)
412. Graphics and Photography in Instruction (3)
414. Television and Motion Pictures in Instruction (3)
415. Systematic Instructional Development (3)
420. Individualized Instruction (3)
440. An Introduction to Computers for Educators (3)
441. Course-Authoring Languages for Educators (3)

496. Independent Studies (1-18)
497. Special Topics (1-9)

511. Organization and Administration of Instructional Systems (3) Procedures and considerations necessary for the effective organization, management, and evaluation of instructional systems. Prerequisite: INSYS 411.

520. Foundations of Instructional Systems (3) An analysis of the applications of systems theory and information technology to instruction. Prerequisites: INSYS 411 or 415.

525. Instructional Systems Design (3) Advanced rational and empirical methods of analyzing and designing instructional systems. Prerequisite: INSYS 415.

532. Research in Instructional Systems (3) Review of recent research findings in instructional systems and their impact on the design of instruction. Prerequisite: EDPSY 400.

540. Computer-Based Instructional Systems (3) A survey of the theory and practice of using computers as instructional aids. Prerequisite: INSYS 440.

541. Design and Development of Microcomputer Courseware (3) The design, development, and implementation of validated microcomputer courseware. Prerequisites: INSYS 441, 525, CMPSC 403.

596. Individual Studies (1-9)

597. Special Topics (1-9)

MATHEMATICS EDUCATION (MTHED)

411. Teaching Secondary Mathematics I (3)
412. Teaching Secondary Mathematics II (3)
420. Teaching Mathematics in the Elementary Schools (3)
422. Individualizing Instruction in School Mathematics (3)
424. Contemporary School Mathematics Programs (3)
427. Computers and the Teaching of Mathematics (3)
470. Selected Studies in Mathematics Education (1-6)
496. Independent Studies (1-18)
497. Special Topics (1-9)

520. Analysis of Research in Mathematics Education (3) Survey of the status of knowledge about mathematics learning and instruction, K-12; analysis of research procedures; instruments for evaluating research. Prerequisites: MTHED 420 or 412; 3 credits in statistics; teaching experience.

525. Research Participation in School Mathematics Curriculum Construction (3) Development of theoretical bases for the construction of instructional materials in mathematics; research participation in preparing and testing curriculum materials.

595. Advanced Clinical Internship in Mathematics Learning (3) Supervised internship in advanced procedures for the implementation of diagnostic/prescriptive approaches as a strategy for improving mathematics learning. Prerequisites: 6 credits in mathematics education.

596. Individual Studies (1-9)

597. Special Topics (1-9)

READING, COMMUNICATION, AND LANGUAGE EDUCATION (RCLED)

400. Teaching Reading in the Elementary School (3)
401. Methods of Teaching Language Arts in Elementary School (3)
402. Teaching Children's Literature (3)
411. Teaching Secondary English I (3)
412. Teaching Secondary English II (3)
420. Teaching Reading and Literature to Adolescents (3)
424. Seminar in Foreign Language and Bilingual Education (3)
425. Methods of Teaching in Bilingual Education (3)
440. Fundamentals of Reading Instruction (3)

442. The Elementary School Language Arts Program (3)
443. Teaching Language and Composition (3)
445. Teaching English in Bilingual/Dialectal Education (3)
446. Remedial Reading in the Classroom (3)
450. Content Area Reading (3)
467. Intergroup Storytelling (3)
470. Selected Studies in Reading, Communication, and Language Education (1-6)
495. School Practicum in Reading (1-18)
496. Independent Studies (1-18)
497. Special Topics (1-9)

526. (EDPSY 526) The Psychology of Reading (3) Psychological principles underlying the process of reading and comprehending, with application to instruction. Prerequisite: EDPSY 421.

540. Teaching Reading: Linguistics Perspective (3) Examination of reading as language and thought processes; contributions of linguistics, orthography, semantics, and syntax to instructional strategies. Prerequisites: undergraduate reading course and teaching experience.

541. Adolescent and Children's Literature Related to Ethnic and Social Issues (3) Literature, K-12; study of literary symbolism, ethnic literature, issues, e.g., sex, death, adoption, divorce in trade books. Prerequisite: RCLED 402.

542. Issues in Reading, Communication, and Language Education (3 per semester, maximum of 6) Issues in curriculum development and research in reading, communication, and language education, K-12; instructional materials analysis and development. Prerequisites: RCLED 401, 412; teaching experience.

544. Cross-Cultural Research in Bilingual Education (3) Analysis of cross-cultural research methodology in bilingual education. Prerequisites: 12 credits in education and/or psychology; 3 credits in statistics.

545. Diagnostic Testing in Reading (3) Diagnosis of reading difficulties; genesis of reading problems; achievement, diagnostic, and capacity tests; application in simulation activities. Prerequisite: RCLED 440.

550. Theory and Practicum in Remedial Reading for Elementary Students (3) Remediation designs analyzed, applied, and evaluated in required supervised practicum with children. Prerequisites: RCLED 401, 440, 545.

551. Theory and Practicum in Remedial Reading for Secondary/Adult Learners (3) Reading problems of secondary/adult/remedial students based on theories and research; application in required supervised practicum. Prerequisites: RCLED 401, 440, 545.

560. (ADTED 560) Teaching Reading to College Students and Adults (3) Reading literacy for adults, including college reading, Adult Basic Education (ABE), and General Educational Development (GED) programs. Prerequisite: RCLED 440 or teaching experience.

565. Analysis of Theory and Practice in Bilingual Education Program (3) Classroom analysis, observation, and research of instructional procedures, materials, and evaluation strategies used in bilingual education. Prerequisites: RCLED 424; 12 credits in education and psychology.

566. Bilingual Education and the Hispanic Child (3) Analysis of the research and literature related to teaching bilingual Hispanic students; examines problems, issues, and strategies. Prerequisites: 12 credits in education and/or psychology.

594. Research in the Teaching of Reading, Communication, and Language Education (3) Cooperative study of problems and research findings in the teaching of reading, communication, and language education in American schools. Prerequisite: C I 400 or EDPSY 400.

595A. Practicum: Remedial Procedures and Diagnosis (3-6) Advanced practicum; diagnostic testing and remedial instruction of more severe types of reading disability; supervisory experiences, if appropriate. Prerequisite: RCLED 545.

595B. Advanced Practicum in Bilingual Education (1-6) Advanced internship in curriculum, supervision, and instruction in bilingual education setting. Prerequisites: 12 credits in education and/or psychology; 12 credits in bilingual education.

596. Individual Studies (1-9)

597. Special Topics (1-9)

SCIENCE EDUCATION (SCIED)

411. Teaching Secondary Science I (3)
412. Teaching Secondary Science II (3)
454. Science in Early Childhood Education (3)
455. Field Natural History for Teachers (3)
456. Teaching of Conservation of Natural Resources in the Schools (3)
457. Teaching of Environmental Education in the Schools (3)
458. Teaching Science in the Elementary School (3)
470. Selected Studies in Science Education (1-6)
496. Independent Studies (1-18)
497. Special Topics (1-9)

556. The Supervision of Science Curriculum (3) Supervision of elementary and secondary science teachers as they develop K-12 programs in the public schools. Prerequisites: 6 credits in science methods, 20 credits in science or equivalent, and teaching experience.

558. Research Problems in Science Teaching (3) Problems and research dealing with curriculum, materials, evaluation, and supervision of science teaching and learning. Prerequisites: SCIED 412 or 458; teaching experience.

559. Analysis of Instruction in Elementary Science Education (3) Analysis of the history, issues, trends, and research in elementary science education. Prerequisites: teaching experience, 3 credits in elementary science methods, and 18 credits of science courses.

596. Individual Studies (1-9)

597. Special Topics (1-9)

SOCIAL STUDIES EDUCATION (SS ED)

411. Teaching Secondary Social Studies I (3)
412. Teaching Secondary Social Studies II (3)
430. Teaching Social Studies in the Elementary Grades (2-3)
470. Issues in Social Studies Education (1-6)
496. Independent Studies (1-18)
497. Special Topics (1-9)

530. Instructional Practices in the Social Studies (3) Social studies innovations in the classroom, new programs, new materials, new methods, and evaluation. Prerequisite: one year of teaching experience.

532. Curriculum Models in Social Studies Education (3) Study of past and proposed curricula in elementary and secondary social studies. Various means of judging curricula will be offered. Prerequisite: C I 495D.

533. Research in the Teaching of Social Studies (3) Procedures and methods of research for the teaching of social studies, strategies of investigation, and review of research literature. Prerequisites: 12 credits in the social sciences on the 400 or 500 level and teaching experience.

596. Individual Studies (1-9)

597. Special Topics (1-9)

DAIRY SCIENCE — See ANIMAL SCIENCE

DEMOGRAPHY (DEMOG)

GORDON F. DE JONG, *In charge*
22 Burrowes Building
814-865-0486

Degrees Conferred: Students electing this option through participating programs will earn a degree with a dual title at both the Ph.D. and M.A. or M.S. levels; i.e., Ph.D. in (graduate program name) and Demography, or M.A. or M.S. in (graduate program name) and Demography.

Senior Members of the Graduate Faculty
Clifford C. Clogg, Ph.D. (Chicago) *Professor of Sociology and Statistics*
Gordon D. De Jong, Ph.D. (Kentucky) *Professor of Sociology*
Henry C. Harpending, Ph.D. (Harvard) *Professor of Anthropology*
Dennis P. Hogan, Ph.D. (Wisconsin) *Professor of Sociology*
Craig R. Humphrey, Ph.D. (Brown) *Associate Professor of Sociology*
Warren C. Robinson, Ph.D. (Princeton) *Professor of Economics*
Wayne A. Schutjer, Ph.D. (Michigan State) *Professor of Agricultural Economics*
Paul D. Simkins, Ph.D. (Wisconsin) *Professor of Geography*
C. Shannon Stokes, Ph.D. (Kentucky) *Professor of Rural Sociology*
Rex H. Warland, Ph.D. (Iowa State) *Professor of Rural Sociology*
Kenneth M. Weiss, Ph.D. (Michigan) *Professor of Anthropology*
Anthony V. Williams, Ph.D. (Michigan State) *Associate Professor of Geography*
Wilbur Zelinsky, Ph.D. (California–Berkeley) *Professor Emeritus of Geography*

Associate Members of the Graduate Faculty
Gretchen T. Cornwell, Ph.D. (Penn State) *Assistant Professor of Rural Sociology*
David J. Eggebeen, Ph.D. (North Carolina) *Assistant Professor of Individual and Family Studies*
Jill L. Findeis, Ph.D. (Washington State) *Assistant Professor of Agricultural Economics*
Daniel T. Lichter, Ph.D. (Wisconsin) *Associate Professor of Sociology*
Michael P. Massagli, Ph.D. (Wisconsin) *Assistant Professor of Sociology*
Jan E. Mutchler, Ph.D. (Texas–Austin) *Assistant Professor of Sociology*
David Shapiro, Ph.D. (Princeton) *Associate Professor of Economics*

The Demography dual-title degree program option is administered by the Demography Program Committee, which is responsible for management of the program. The committee includes at least one faculty member from each participating department. The committee maintains program definition, identifies faculty and courses appropriate to the option, and recommends policies and procedures for its operation to the dean of the Graduate School. This dual-title degree program is offered as an option to graduate major programs in three colleges: Agriculture, Earth and Mineral Sciences, and Liberal Arts. The option enables students from diverse graduate programs to attain and be identified with the content, techniques, methodology, and policy implications of demography, while maintaining a close association with areas of application. Through demography, students study (1) the size, composition, and distribution of the population; (2) changes in these characteristics; (3) the processes that determine these changes — fertility, migration, and mortality; and (4) their social, economic, and cultural causes and consequences. To pursue a dual-title degree under this program option, the student must apply to the Graduate School and register through one of the following graduate programs: Agricultural Economics, Anthropology, Economics, Geography, Rural Sociology, or Sociology.

Admission Requirements
Scores from the Graduate Record Examination (GRE) are required for admission. At the discretion of a graduate program, a student may be admitted provisionally for graduate study in a program without these scores. Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin*.

There are no prerequisites for admission to the M.A., M.S., or Ph.D. program options other than those imposed by the participating graduate programs.

All application materials should be submitted by February 15. Applicants should have a junior-senior cumulative average of at least 3.00 (on a 4.00 scale) and appropriate courses in statistics and in

the social science department to which they are applying. The application should include three letters of reference and a statement describing and explaining the applicant's interest in demography and goals during and after graduate study. TOEFL scores are required of all students for whom English is a second language.

Degree Requirements

To qualify for a dual-title degree, students must satisfy the requirements of the graduate program in which they are enrolled, including the communication/foreign language requirements, if any. In addition, they must satisfy the minimum requirements in the Demography option described below, as established by the Demography Program Committee. Within this framework, final course selection is determined by students and their degree committees. All dual-title degree candidates who are in residence are expected to enroll in DEMOG 590 for at least 1 credit each year.

Master's Degree: For the M.A. and M.S. degree with the Demography option, 12 course credits are required in addition to the colloquium credit or credits. A minimum of 3 credits is required in each of the following areas: (1) Disciplinary Perspective Courses — ANTH 473, ECON 463, GEOG 405, SOC 423; (2) Demographic Method Courses — ANTH 408, GEOG 457, SOC 473, 576; (3) Demography Seminars — DEMOG 597, ECON 560, GEOG 509, R SOC 525, SOC 521, 523, 554.

Particular courses may satisfy both the graduate major program requirements and those of the Demography option. The thesis supervisor must be a member of the graduate faculty recommended by the chair or the graduate officer of the program granting the degree and approved by the Demography Program Committee as qualified to supervise thesis work in demography. If a no-thesis option is available in the student's graduate program, a paper or report may be written in lieu of the M.A. or M.S. thesis. A student selecting the paper instead of a thesis must take an additional 3 credits in the Demography option.

Ph.D. Degree: For the Ph.D. degree with the Demography option, a minimum of 24 credits (a minimum of 27 credits for students who completed a nonthesis M.A. or M.S. program) is required. For students entering with a master's degree from another institution, equivalent course credits may be accepted. Up to 3 of the required minimum credits may be in colloquium credits. A minimum of 6 credits must be in demography methods courses (ANTH 408, GEOG 457, SOC 473, 576) with the balance from disciplinary demographic perspective courses, demography seminars, and demography special topic or individual studies credits. Final course selection is determined in consultation with the doctoral committee.

The doctoral committee is recommended by the graduate major program granting the degree. A five-member committee is required for a dual-title degree program. The chair and at least one additional member of the doctoral committee must be members of the graduate faculty approved by the Demography Program Committee as qualified to supervise doctoral theses in demography. The Demography faculty members on the student's committee are responsible for administering an examination in demography that constitutes a portion of the comprehensive examination of the doctoral student in the program option. A dissertation on a demographic topic is required of students in the dual-title degree program.

Other Relevant Information

A Ph.D. minor in Demography is available for doctoral students in graduate programs who find it advantageous to include demographic content, methods, and policy analysis in their program of study. The student's doctoral committee must approve the choice of this minor, and one member of the doctoral committee must be from the Demography faculty.

To qualify for a minor in Demography, students must satisfy the requirements of their graduate major program and take at least 15 credits in demography in addition to colloquium credits. A minimum of at least 3 credits each in (1) disciplinary perspective and (2) demographic methods courses and 6 credits in demography seminar courses are required. Students must enroll in DEMOG 590 for at least 1 credit during each year enrolled in the program and in residence.

Student Aid

In addition to the fellowships, traineeships, graduate assistantships, and other forms of financial aid described in the STUDENT AID section of the *Graduate Bulletin,* the following award typically has been available to graduate students in this program:

HEWLETT FOUNDATION AWARDS — Available to demography students from developing countries.

DEMOGRAPHY (DEMOG)

590. COLLOQUIUM (1-3) Continuing seminars which consist of a series of individual lectures by faculty, students, or outside speakers.
596. INDIVIDUAL STUDIES (1-9)
597. SPECIAL TOPICS (1-9)

DEVELOPMENTAL AND REMEDIAL READING (DRR)

ROBERT L. SHRIGLEY, *Coordinator for Graduate Studies in Developmental and Remedial Reading*
168 Chambers Building
814-865-5433

Degree Conferred: M.Ed.

Senior Members of the Graduate Faculty
Eunice N. Askov, Ph.D. (Wisconsin) *Professor of Education*
Mary M. Dupuis, Ph.D. (Penn State) *Professor of Education*
Jane M. Madsen, Ed.D. (Arizona State) *Associate Professor of Education*

Associate Member of the Graduate Faculty
Frances E. Fairchild, D.Ed. (Missouri) *Associate Professor of Education*

The purpose of the master's program is to prepare classroom teachers in elementary and secondary schools for more effective teaching of reading and to provide preparation for supervisory and administrative positions relative to reading in school systems.

The master's program has been planned so that those completing the program will also meet the state requirements for "reading specialist" certification.

Admission Requirements
Scores from the Miller Analogies Test (MAT) are required for admission. At the discretion of a graduate program, a student may be admitted provisionally for graduate study in a program without these scores. Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin*.

Candidates for a master's degree must meet the requirements for admission to graduate study. In addition, they (1) must hold, or be eligible to hold, a valid teaching certificate in elementary, secondary, or special education (persons not meeting this criterion may work on overcoming deficiencies; graduate credit, but not degree credit, may be received for graduate courses taken to overcome such deficiencies); and (2) must have had at least one year of teaching experience or equivalent.

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

Student Aid
In addition to the fellowships, traineeships, graduate assistantships, and other forms of financial aid described in the STUDENT AID section of the *Graduate Bulletin,* the following award typically has been available to graduate students in this program:

U.S. OFFICE OF EDUCATION BILINGUAL EDUCATION FELLOWSHIPS — Available to Ph.D. and D.Ed. candidates preparing for professional careers in bilingual education or a related field; stipend $5,400 plus tuition, books, and fees. Apply to Director, Bilingual Education Program, Division of Curriculum and Instruction, College of Education.

EARTH SCIENCES (EARTH)

CHARLES THORNTON, *In Charge of Graduate Programs in Earth Sciences*
539 Deike Building
814-865-4462

Degrees Conferred: D.Ed., M.Ed.

Senior Members of the Graduate Faculty
Alfred K. Blackadar, Ph.D. (NYU) *Professor of Meteorology*
John J. Cahir, Ph.D. (Penn State) *Professor of Meteorology*
John H. E. Clark, Ph.D. (Florida State) *Associate Professor of Meteorology*
Roger J. Cuffey, Ph.D. (Indiana) *Professor of Paleontology*
Rosa G. de Pena, Ph.D. (Buenos Aires) *Professor of Meteorology*
John A. Dutton, Ph.D. (Wisconsin) *Professor of Meteorology*
Charles L. Hosler, Ph.D. (Penn State) *Professor of Meteorology*
Peter M. Lavin, Ph.D. (Penn State) *Associate Professor of Geophysics*
Peirce F. Lewis, Ph.D. (Michigan) *Professor of Geography*
John J. Olivero, Jr., Ph.D. (Michigan) *Associate Professor of Meteorology*
Robert F. Schmalz, Ph.D. (Harvard) *Professor of Geology*
Dennis W. Thomson, Ph.D. (Wisconsin) *Professor of Meteorology*
Charles P. Thornton, Ph.D. (Yale) *Professor of Petrology*
Alfred Traverse, Ph.D. (Harvard) *Professor of Palynology*
Frederick L. Wernstedt, Ph.D. (UCLA) *Professor of Geography*
Eugene G. Williams, Ph.D. (Penn State) *Professor of Geology*
Lauren A. Wright, Ph.D. (California Tech.) *Professor of Geology*

Associate Member of the Graduate Faculty
Brent M. Yarnal, Ph.D. (Simon Fraser) *Assistant Professor of Geography*

The M.Ed. program is designed to meet the needs of science teachers in elementary and secondary schools. The D.Ed. program is designed for secondary school and college science teachers. The earth science fields of study are geography, geological sciences (geology, geochemistry and mineralogy, or geophysics), and meteorology.

Admission Requirements

Scores from the Graduate Record Examination (GRE) Aptitude Test (verbal and quantitative) are required for completion of the admission process. At the discretion of a graduate program, a student may be admitted provisionally for graduate study in a program without these scores. Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin*.

Students with a 2.50 junior-senior average, 18 credits in education and related psychology, and 6 credits in earth science fields or other appropriate background will be considered for admission to the M.Ed. program. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests. The M.Ed. program is not offered during the summer session.

In order to enter the D.Ed. program a candidate should present evidence of competence at the baccalaureate level in one of the earth sciences (geography, geological sciences, or meteorology) or in an allied science curriculum. Students with a 2.70 junior-senior average and with appropriate course backgrounds will be considered for admission. Exceptions to the minimum 2.70 grade-point average will be made for students with special backgrounds, abilities, and interests.

Master's Degree Requirements

The M.Ed. candidate selects one of the earth sciences as an area of concentration, takes at least 12 credits in it, and is required to write a paper in that area. An additional 12 credits must be taken in the other two fields of earth sciences; or 6 credits may be taken in one of the earth science fields plus 6 credits in other science or engineering fields. Two education courses, C I 400 and SCIED 558, are required as a minor.

Doctoral Degree Requirements

The course requirements are planned by the candidate's committee. A minimum of 60 credits must include one area of concentration within the earth sciences — geography, geological sciences (geology, geochemistry and mineralogy, or geophysics), or meteorology — plus courses from each of the

other two earth science areas. A minimum of 15 credits each is required in professional education and in thesis research. The thesis topic must be in one of the earth sciences. Three consecutive semesters of residence are required for the D.Ed. degree. The student's D.Ed. committee shall normally consist of five members — two members from the area of concentration, one member from each of the other two earth science fields, and one member from education.

Student Aid
Graduate assistantships available to students in this program and other forms of student aid are described in the STUDENT AID section of the *Graduate Bulletin*.

EARTH SCIENCES (EARTH)

400. Earth Sciences Seminar (3)
496. Independent Studies (1-18)
497. Special Topics (1-9)

500. Earth Sciences Research (1-6) Relationships between the earth sciences revealed by theory, analytical methods, or a selected problem.

ECOLOGY (ECLGY)

EDWARD D. BELLIS, *In Charge of Graduate Programs in Ecology*
311 Erwin W. Mueller Laboratory
814-865-3942

Degrees Conferred: Ph.D., M.S.

Senior Members of the Graduate Faculty
Dean E. Arnold, Ph.D. (Cornell) *Adjunct Assistant Professor of Aquatic Ecology*
Dale E. Baker, Ph.D. (Missouri) *Professor of Soil Chemistry*
Stephen Beckerman, Ph.D. (New Mexico) *Assistant Professor of Anthropology*
Edward D. Bellis, Ph.D. (Minnesota) *Professor of Biology*
#Jean-Marc Bollag, Ph.D. (Basel) *Professor of Soil Microbiology*
E. Alan Cameron, Ph.D. (California) *Professor of Entomology*
*Robert F. Carline, Ph.D. (Wisconsin) *Adjunct Associate Professor of Fish and Wildlife Science*
#Lester E. Casida, Jr., Ph.D. (Wisconsin) *Professor of Microbiology*
Roger J. Cuffey, Ph.D. (Indiana) *Professor of Paleontology*
Donald D. Davis, Ph.D. (Penn State) *Professor of Plant Pathology*
David R. DeWalle, Ph.D. (Colorado State) *Professor of Forest Hydrology*
William A. Dunson, Ph.D. (Michigan) *Professor of Biology*
Richard H. Fox, Ph.D. (Arizona) *Professor of Soil Science*
Albert L. Guber, Ph.D. (Illinois) *Professor of Geology*
Arthur A. Hower, Jr., Ph.D. (Penn State) *Professor of Entomology*
Carl S. Keener, Ph.D. (North Carolina State) *Associate Professor of Biology*
Ke Chung Kim, Ph.D. (Minnesota) *Professor of Entomology*
*C. Gregory Knight, Ph.D. (Minnesota) *Professor of Geography*
Jeffrey A. Kurland, Ph.D. (Harvard) *Associate Professor of Anthropology*
*Bruce G. Lindsay, Ph.D. (Washington) *Professor of Statistics*
Larry H. McCormick, Ph.D. (Penn State) *Associate Professor of Forest Resources*
*Archibald J. McDonnell, Ph.D. (Penn State) *Professor of Civil Engineering*
*Wayne L. Myers, Ph.D. (Michigan) *Associate Professor of Forest Biometrics*
*Ganapati P. Patil, Ph.D. (Michigan) D.Sc. *Professor of Mathematical Statistics*
David L. Pearson, Ph.D. (Washington) *Associate Professor of Biology*
*James L. Rosenberger, Ph.D. (Cornell) *Associate Professor of Statistics*
Robert D. Shipman, Ph.D. (Michigan State) *Professor of Forest Ecology*
John D. Skelly, Ph.D. (Penn State) *Professor of Plant Pathology*
Zane Smilowitz, Ph.D. (Cornell) *Professor of Entomology*
William E. Sopper, Ph.D. (Yale) *Professor of Forest Hydrology*
Jay R. Stauffer, Jr., Ph.D. (Virginia Polytechnic) *Associate Professor of Fishery Science*
Kim C. Steiner, Ph.D. (Michigan State) *Professor of Forest Genetics*
Andrew G. Stephenson, Ph.D. (Michigan) *Professor of Biology*
#S. Edward Stevens, Jr., Ph.D. (Texas) *Professor of Microbiology and Cell Biology*
#Richard F. Unz, Ph.D. (Rutgers) *Professor of Sanitary Microbiology*

*#Frederick M. Williams, Ph.D. (Yale) *Associate Professor of Biology*
Richard H. Yahner, Ph.D. (Ohio State) *Associate Professor of Wildlife Management*

Associate Members of the Graduate Faculty
Marc D. Abrams, Ph.D. (Michigan State) *Assistant Professor of Forest Ecology and Physiology*
William S. Abruzzi, Ph.D. (SUNY-Binghamton) *Assistant Professor of Anthropology*
Robert P. Brooks, Ph.D. (Massachusetts) *Associate Professor of Wildlife Ecology*
*Andrew G. Clark, Ph.D. (Stanford) *Associate Professor of Biology*
Roger Koide, Ph.D. (California) *Assistant Professor of Biology*
Walter Kremers, Ph.D. (Cornell) *Assistant Professor of Statistics*
Les E. Lanyon, Ph.D. (Ohio State) *Associate Professor of Soil Fertility*
#James R. Pratt, Ph.D. (Virginia Polytechnic) *Assistant Professor of Aquatic Ecology*
Jack C. Shultz, Ph.D. (Washington) *Assistant Professor of Entomology*
William E. Sharpe, Ph.D. (West Virginia) *Associate Professor of Forest Resources Extension*
Christopher Uhl, Ph.D. (Michigan State) *Associate Professor of Biology*
*#Thomas S. Whittam, Ph.D. (Arizona) *Assistant Professor of Biology*

This intercollege program emphasizes the properties of ecosystems by focusing attention on interactions of single organisms, populations, and communities with their environment. It is designed to give students a basic understanding of ecological theory and research techniques and is complementary to other environmental programs that emphasize the human role in ecosystems.

The program is administered by a committee drawn from faculty members in several departments and colleges of the University. This committee and its chair are appointed by the dean of the Graduate School. The instructional staff is composed of participating faculty in those departments offering graduate courses in fields closely allied to ecology.

The committee appointed by the Graduate School for each candidate in Ecology is selected from faculty in the student's area of specialization. The committee has the responsibility for determining the course program and research acceptable in satisfying degree requirements.

Quantitative and Microbial Options — Two options for specialization are offered: the Quantitative Ecology option and the Microbial Ecology option. The quantitative option includes mathematical and statistical modeling and applications of statistics to experimental design and data analysis. The microbial option includes basic aquatic and soil microbial ecology and applications to recycling of materials and release of genetically engineered organisms. Each option entails extra course requirements plus a thesis directed by an ecology faculty member in the option. Quantitative option faculty are designated above by (*), and microbial option faculty by (#). Additional information can be obtained from the option chairs: F. M. Williams, quantitative; or S. E. Stevens, microbial. All formal application materials, however, are to be sent to the program chair, E. D. Bellis.

Admission Requirements
Scores from the Graduate Record Examination (GRE), including verbal, quantitative, and an advanced test, are required for admission. Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin.*

Students meeting the admission requirements of the Graduate School will be considered up to the number of spaces available in selecting candidates in this program. Candidates should have a strong science background, including chemistry through organic chemistry, mathematics through calculus, physics, and biology. A limited number of such courses can be made up while the student is pursuing graduate study. Students with a unique background in another discipline which has potential value to original ecological work will be seriously considered. A junior-senior grade-point average of 3.00 or better is required.

Students are strongly urged to choose their research interests and initiate communication with the relevant faculty member(s) before applying for admission. This is especially crucial if the student is seeking financial aid. Teaching and research assistantships are available only through the student's faculty adviser.

Formal applications along with GRE scores should be sent to the Graduate School. The applicant should forward the following *directly to the program chair:* (1) three or more letters of recommendation regarding the student's academic and professional promise; and (2) a concise one-page statement describing the student's goals both within the program and in professional life. Specific inquiries about the Ecology program may be directed to the program chair.

Degree Requirements
The instructional program includes three graduate core courses in ecology, augmented by an additional integrated group of seminars and courses selected for each student by the committee, and a re-

search project directed by the thesis adviser. The nonthesis option is available for the M.S. degree, at the adviser's discretion.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by strong performance in two semesters of one foreign language or the equivalent.

Other Relevant Information
Detailed descriptions of courses now available for students majoring in Ecology may be found under the offerings of several ecologically oriented departments.

Student Aid
Graduate assistantships available to students in this program and other forms of student aid are described in the STUDENT AID section of the *Graduate Bulletin*.

ECOLOGY (ECLGY)

590. COLLOQUIUM (1-3)

ECONOMICS (ECON)

JAMES D. RODGERS, *Head of the Department*
613 Kern Graduate Building
814-865-1456

Degrees Conferred: Ph.D., M.A.

Senior Members of the Graduate Faculty
Eric W. Bond, Ph.D. (Rochester) *Associate Professor of Economics*
Irwin Feller, Ph.D. (Minnesota) *Professor of Economics*
James B. Herendeen, Ph.D. (Penn State) *Professor of Economics*
Teh-Wei Hu, Ph.D. (Wisconsin) *Professor of Economics*
Philip A. Klein, Ph.D. (California) *Professor of Economics*
Raymond E. Lombra, Ph.D. (Penn State) *Professor of Economics*
Jon P. Nelson, Ph.D. (Wisconsin) *Professor of Economics*
Jan S. Prybyla, Ph.D. (N.U.-Ireland) *Professor of Economics*
John H. Riew, Ph.D. (Wisconsin) *Professor of Economics*
Mark J. Roberts, Ph.D. (Wisconsin) *Associate Professor of Economics*
Warren C. Robinson, Ph.D. (Princeton) *Professor of Economics*
James D. Rodgers, Ph.D. (Virginia) *Professor of Economics*
Marvin E. Rozen, Ph.D. (California) *Professor of Economics*
Larry W. Samuelson, Ph.D. (Illinois) *Professor of Economics*
David Shapiro, Ph.D. (Princeton) *Associate Professor of Economics*
Joseph V. Terza, Ph.D. (Pittsburgh) *Associate Professor of Economics*

Associate Members of the Graduate Faculty
Shaghil Ahmed, Ph.D. (Rochester) *Assistant Professor of Economics*
N. Edward Coulson, Ph.D. (California-San Diego) *Assistant Professor of Economics*
Keith J. Crocker, Ph.D. (Carnegie-Mellon) *Associate Professor of Economics*
Dean D. Croushore, Ph.D. (Ohio State) *Assistant Professor of Economics*
Theresa J. Devine, Ph.D. (Cornell) *Assistant Professor of Economics*
John Fender, M.Phil. (Oxford) *Associate Professor of Economics*
Thomas G. Fox, Ph.D. (Syracuse) *Professor of Economics*
Barry W. Ickes, Ph.D. (California) *Assistant Professor of Economics*
Donald S. Kenkel, Ph.D. (Chicago) *Assistant Professor of Economics*
Bee-yan Roberts, Ph.D. (Wisconsin) *Assistant Professor of Economics*
Richard Rosenberg, Ph.D. (Minnesota) *Associate Professor of Economics*
Ping Wang, Ph.D. (Rochester) *Assistant Professor of Economics*
B. San Yoo, Ph.D. (California-San Diego) *Assistant Professor of Economics*

Opportunities are available for concentration in the following fields: economic theory, econometrics, economic development, economic fluctuations, comparative economic systems, income distribution, industrial organization, international economics, labor economics, mathematical economics, monetary theory and policy, public finance, and urban and regional economics. In addition to the courses

offered in the above areas, formal graduate course work is available in economic demography, environmental economics, economics of education, health economics, economics of technological change, economic doctrines, and economic development of developed areas.

Students also may qualify for admission to the Demography option, consisting of interdisciplinary course work, with special emphasis on the economic, social, and geographic issues arising from the dynamics of population change.

Admission Requirements

Scores from the Graduate Record Examination (GRE) general tests are required for admission. At the discretion of the department, a student may be admitted provisionally for graduate study without these scores, but must take the GRE general test by the end of the first semester of study. Whenever possible, scores on the GRE advanced economics test should also be provided. Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin*.

Students entering the master's program should have at least 6 credits in economics, 3 credits in statistics, and 3 credits in calculus. Students entering the doctoral program should have successfully completed at least 6 credits in economics, 3 credits in statistics, and 6 credits in calculus. Course work in linear algebra is also strongly recommended. Students entering the doctoral program need not have a master's degree. Students are permitted to enter the master's and doctoral programs with deficiencies but must pass courses to eliminate deficiencies as soon as possible.

Students with a 2.50 junior-senior grade-point average, a 3.00 average in economics courses, and appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum grade-point averages may be made for students with special backgrounds, abilities, and interests.

Degree Requirements

Requirements for the M.A. degree are satisfactory completion of ECON 480, 490, 502, and 503, plus 18 additional credits including at least 6 credits in a major field of specialization in economics. A maximum of 6 credits can be elected in course work outside economics. The nonthesis option is available for the M.A. degree.

For the Ph.D. degree, all students are required to take a written candidacy examination during their second year. Written comprehensive examinations are required in economic theory and in two applied fields chosen by the student. Students must satisfactorily complete courses in econometrics and in a third field. The latter may be outside of economics.

The Department of Economics has no formal foreign language or communication skill requirement. The student, however, is expected to display a high degree of proficiency in written and spoken English and is encouraged to pursue additional training in foreign languages, technical writing, mathematics, statistics, and computer science as will support dissertation and career goals.

Other Relevant Information

Students in this program may elect the dual-title degree program option in Operations Research for the Ph.D. and M.S. degrees (see p. 326). The nonthesis option is available for the M.S. degree.

Student Aid

Graduate assistantships available to students in this program and other forms of student aid are described in the STUDENT AID section of the *Graduate Bulletin*.

ECONOMICS (ECON)

400. History of Economic Thought I (3)
401. History of Economic Thought II (3)
404. Current Economic Issues (3)
405. Seminar in Economic Analysis (3)
407. (COMM 407) Advertising in the American Economy (3)
412. Labor Market Policy and Collective Bargaining (3)
423. State and Local Taxation (3)
425. Economics of Public Expenditures (3)
427. (EDADM 427) Economics of Education (3)
428. Environmental Economics (3)
429. Public Finance and Fiscal Policy (3)

433. Advanced International Economics (3)
445. (H P A 445) Health Economics (3)
450. The Business Cycle (3)
451. Monetary Theory and Policy (3)
463. Economic Demography (3)
480. Mathematical Economics (3)
489H. Honors Thesis (3-6)
490. Introduction to Econometrics (3)
496. Independent Studies (1-18)
497. Special Topics (1-9)
499. Foreign Study — Economics (2-6)

500. Economic Seminar (3-6)

502. Microeconomic Analysis (3) Economic behavior under pure and imperfect competition; price and output determination in product markets; prices and employment in factor markets.

503. Macroeconomic Analysis (3) National income accounts; determination of income, employment, interest rates, and the price level; stabilization policy.

506. Problems in Economics (1-12) Planned projects involving library, laboratory, or field work.

507. International Trade (3) Theory of international trade and investment; effect of commercial policy on trade and income distribution; multinational corporations and international trade.

510. (AG EC 510) Econometrics I (3) General linear model, multicollinearity, specification error, autocorrelation, heteroskedasticity, restricted least squares, functional form, dummy variables, limited dependent variables. Prerequisite: ECON 490 or STAT 462 or 501.

511. (AG EC 511) Econometrics II (3) Stochastic regressors, distributed lag models, pooling cross-section and time-series data, simultaneous equation models. Prerequisite: ECON (AG EC) 510.

513. Development of Economic Doctrines (3-6)

515. Labor Economics I (3) Labor supply and income maintenance; human capital, job search and training; labor demand, minimum wage, and discrimination.

516. Labor Economics II (3) Earnings differentials, unemployment, and related policy. Institutional aspects of labor economics, including dual labor markets, collective bargaining, and unionism.

517. International Finance (3) Balance of payments and methods of adjustment; economics of exchange rates; international liquidity and financial institutions; selected policy issues.

521. Advanced Microeconomic Theory (3-6) Theory of consumer behavior; theory of the firm; price determination in product and factor markets; introduction to welfare economics.

522. Advanced Macroeconomic Theory (3-6) Measurement of income; theories of consumption, investment, and money holdings; static determination of income and employment; introduction to dynamic analysis.

524. Income Distribution (3-6) Measurement of inequality; ethical issues of income redistribution; explaining income and wealth differences; problems of poverty.

525. Economics of Technological Change (3) Theoretical and empirical analysis of invention and innovation and their effects on productivity, employment, and market structure.

529. Public Finance (3-6) Effects of taxes, expenditures, debt on allocation, employment, distribution; cost-benefit analysis; collective decision mechanisms; fiscal federalism; current fiscal policy problems.

530. Spatial Economic Theory (3) Location theory; analysis of market areas and spatial price behavior; central place theory.

531. Regional Economics (3) Theories and analysis of levels of regional economic activity; growth policies and strategies; evaluation.

532. Urban Economics (3) Urban structure; migration of capital and households; urban public finance.

543. Industrial Organization and Public Policy (3-6) The structure of American industry; performance and behavior; public policies toward business.

550. Economic Fluctuations (3) Analysis of the various theories of economic fluctuations; their methodological premises.

551. Stabilization Policy (3) Description and analysis of the alternatives and issues in stabilization policy.

558. Development of Monetary Theory (3) Classical and neoclassical quantity theories of money and contemporary criticism; Keynesian monetary theory and its critics.

559. Current Monetary Theory and Policy (3) Post-Keynesian reformulation of quantity and Keynesian theories of money; liquidity and general equilibrium approaches; current issues in theory and policy.

560. Development Economics (3-6) Resources and institutions; quantitative measures; theories of economic growth in developing areas; developmental policies.

561. Theories of American Economic Growth (3-6) Growth models; strategic factors in growth; quantification problems; public policy.

571. Comparative Economic Systems (3-6) Comparative analysis of alternative resource allocation principles; growth and performance of different economic systems; problems of decision making and control.

572. Soviet and Other Centrally Planned Economies (3-6) Principles, structure, and performance of centrally planned economies, with special emphasis on the Soviet Union.

580. Mathematical Economics (3-9) Mathematical development of static and dynamic economic models: partial and general equilibrium analysis; growth dynamics; mathematical programming. Prerequisite: ECON 480.

589. (AG EC 589) Seminar in Econometric Theory (3) Theories and methods relevant to the application of statistical methods to economics. Prerequisite: ECON (AG EC) 510.

596. Individual Studies (1-9)

597. Special Topics (1-9)

EDUCATIONAL ADMINISTRATION (EDADM)

WILLIAM E. CALDWELL, *In Charge of Graduate Programs in Educational Administration*
319 Rackley Building
814-865-1487

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Senior Members of the Graduate Faculty
William Lowe Boyd, Ph.D. (Chicago) *Professor of Education*
Paul V. Bredeson, Ph.D. (Wisconsin) *Associate Professor of Education*
William E. Caldwell, Ph.D. (NYU) *Professor of Education*
William T. Hartman, Ph.D. (Stanford) *Associate Professor of Education*
Patrick D. Lynch, Ph.D. (Minnesota) *Professor of Education*
Donald J. Willower, Ed.D. (Buffalo) *Professor of Education*

Associate Member of the Graduate Faculty
G. Mike Charleston, Ph.D. (Penn State) *Associate Professor of Education*

Graduate work in Educational Administration is available to those who want to exercise leadership roles in educational policy and management or engage in research. Among those roles are principals, supervisors, and superintendents of public and independent schools, intermediate unit officials, state and federal agency administrators and staff, professors of educational administration, and research and development personnel. Special areas of research are organization theory, school law, negotiations, personnel and staff development, economics and finance in education, application of modern

technology, leadership, politics of education, philosophical issues in educational administration,and international comparative educational administration. Internships and practicums in a variety of settings can be arranged.

Admission Requirements

Scores from the Miller Analogies Test (MAT) are required for admission to the graduate programs in Educational Administration. When the MAT is not available (e.g., some overseas locations), Graduate Record Examination (GRE) scores may be substituted. At the discretion of a graduate program, a student may be admitted provisionally. Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin*.

Applicants to the M.Ed. and M.S. degree programs must present evidence of at least a 2.60 grade-point average in the last two years of undergraduate work. A grade-point average of 3.50 in prior graduate work is required of those desiring admission to enter a doctoral program. The best-qualified students will be accepted up to the number of spaces available. Special backgrounds and experiences may allow for conditional admission to those not meeting stated criteria.

More details concerning the degree and certification programs are presented in a prospectus that is available upon request. Students in the M.S. and Ph.D. programs in Educational Administration may elect the dual-title degree program option in Operations Research (see p. 326).

Master's Degree and Certification Requirements

All candidates for the M.Ed. and M.S. degrees will complete a minimum of 30 graduate credits. Certification for various public school administrative positions requires additional graduate work beyond the master's degree and such requirements as specified in the program prospectus. In cooperation with this program, certain institutions of higher education in Pennsylvania offer graduate work that leads to certification.

M.Ed. students must submit a master's paper. M.S. degree students are expected to submit a thesis.

Doctoral Degree Requirements

Candidates for the D.Ed. degree are required to spend at least one semester and one summer session consecutively in full-time residence during a twelve-month period. Ph.D. candidates are strongly encouraged to spend two academic years in residence, but must spend at least two consecutive semesters in residence. D.Ed. candidates may make application to satisfy the residence requirement in another manner consistent with Graduate School policy, if they can furnish satisfactory reasons for such a request. Candidates for all degrees are required to combine work in the social sciences and humanities with the specialization in Educational Administration.

Expectations of candidates for both the D.Ed. and Ph.D. are high in the field of research competence and require the ability to identify and conceptualize a research problem for the thesis. The D.Ed. is more appropriate for those with career goals in administration and policy making. The Ph.D. is more appropriate for those with career goals in research and scholarship.

After the doctoral student has been admitted to a doctoral program and has completed forty to forty-five hours beyond the bachelor's degree, his or her name is usually submitted for candidacy. After a student is admitted to candidacy for the doctoral degree, he or she takes the comprehensive written and oral examinations. After those are successfully completed, the student presents a thesis problem on a significant, researchable topic, evidenced by a prospectus to the doctoral committee for review.

Other Relevant Information

American Indian students participate in a special administrator preparation program. Foreign students can work on research topics in their home nations.

Student Aid

Graduate assistantships available to students in this program and other forms of student aid are described in the STUDENT AID section of the *Graduate Bulletin*.

EDUCATIONAL ADMINISTRATION (EDADM)

427. (ECON 427) Economics of Education (3)
476. The Teacher and the Law (3)
480. Introduction to Educational Administration (2-3)
481. Collective Bargaining in Education (3)

496. Independent Studies (1-18)
497. Special Topics (1-9)

502. (EDTHP 502) Educational Planning Techniques in Developing Countries, Part I (3) The introduction of systematic analysis, methodologies, and analytical techniques of education programs and projects to aid decision making in education planning.

503. (EDTHP 503) Educational Planning Techniques in Developing Countries, Part II (3) The application of systematic analysis to relevant education planning cases that illustrate alternate solutions to particular problems of developing countries. Prerequisite: EDTHP 502.

525. Federal Policy and Local Education (3) Historic and contemporary roles of the federal government in education; includes proposal-writing techniques.

528. Educational Politics in the United States (3) Social and institutional forces which shape the public school system and determine national, state, and local educational policy and politics.

533. The Politics of Local School Districts (3) Theory and practice of the politics and governance of local school districts; issues and methods in studying political decision making. Prerequisites: 6 credits of sociology, anthropology, or political science.

550. Evaluating Costs and Benefits in Education (3) The theory and practice of program evaluation using economic tools and policy applications; limitations of these techniques. Prerequisites: 6 credits in the social sciences.

551. Equity Issues and Educational Administration (3) Alternative measures of educational and economic inequality; the interaction of education and family background; administrative options for reducing inequality. Prerequisites: EDADM 480; an introductory course in statistics.

565. Personnel Management and Contract Administration (2-3) Practice and theory of personnel supervision at the central office and building level, including contract administration and grievance handling. Prerequisites: 18 credits in education and three years' teaching experience.

566. Bureaucratic Politics and Educational Policy (3) The political economy and bureaucratic politics of educational organizations, with special attention to the policy-making, implementation, and evaluation processes. Prerequisite: EDADM 528 or 533.

567. Organizational Supervision (3) Principles and practices of supervision in schools related to instructional and support personnel. Prerequisites: EDADM 480, teaching experience.

568. The Principalship (2-3) Principles and practices of administration of elementary and secondary schools.

569. Decision Making in Educational Organizations (2-3) Decision making in organizational and environmental contexts; case studies of administrative problems; application of decision-making models. Prerequisite: EDADM 480.

571. Educational Facilities Planning (2-3) Educational facilities planning, including use of demographic, curriculum, resource, energy data, and state building construction guidelines. Prerequisite: EDADM 480 or teaching or administrative or supervisory experience.

573. Public School Finance (2-3) Financing of public education in relation to organization and control; the conceptual basis for local financial administration; taxation, state and federal aid, school revenue, and money management. Prerequisite: EDADM 480 or teaching or administrative or supervisory experience.

574. Theory and Current Issues in Public Bargaining (2-3) Theories of bargaining; legal basis for public bargaining; state and federal labor relations agencies; supervisory bargaining. Prerequisite: EDADM 481 or administrative experience.

575. (ADTED 575) Administration of Adult Education (3) Organization of a program of adult education; legal status, finances, selection of teachers, learning personnel, housing; other administrative problems. Prerequisite: EDADM 480 or teaching or administrative or supervisory experience.

576. The Law and Education (3) Legal bases for education; rights and responsibilities of school board members, administrators, teachers, students, and parents; due process. Prerequisite: EDADM 480 or teaching or administrative or supervisory experience.

577. Economic Dimensions of Educational Administration (3) Application of selected economic concepts and tools of analysis to administrative decision and planning processes in educational systems. Prerequisite: EDADM 480.

578. Schools as Organizations (2-3) Intraorganizational relationships; administration and the school in its organizational and environmental contexts. Prerequisite: EDADM 480 or teaching or administrative or supervisory experience.

579. Public School Business Administration (2-3) Business management applied to school management problems; budgeting, accounting, purchasing, insurance, school equipment, cafeteria management; transportation, salaries, personnel management, and auxiliary and coordinate agencies. Prerequisites: EDADM 480 or teaching or administrative or supervisory experience; EDADM 573.

580. The Use of Theory in Educational Administration (1-6) Critical analysis of current theories; problem finding and hypothesis formulation. Prerequisites: EDADM 480; 6 credits in educational administration.

581. Field Research in Educational Administration (2-3) Field study and qualitative methods in research on educational organizations. Prerequisites: EDADM 480; 6 credits in educational administration.

584. Evaluation in Educational Organizations (3) Naturalistic and empirical evaluation methods and procedures for educational organizations. Prerequisites: a course in educational administration; a course in basic statistics.

594. Seminar in School Law (3) Research in substantive issues in school law. Prerequisite: EDADM 576.

595. Internship in Administration and Supervision (1-15) Guided experience in a school or other educational organization in which the student is not regularly employed, under supervision of a graduate faculty member. Prerequisites: EDADM 480, teaching experience, and a professional certificate.

596. Individual Studies (1-9)

597. Special Topics (1-9)

EDUCATIONAL PSYCHOLOGY (EDPSY)

JOSEPH L. FRENCH, *In Charge of Graduate Programs in Educational Psychology*
101 Cedar Building
814-865-1881

Degrees Conferred: Ph.D., M.S.

Senior Members of the Graduate Faculty
Francis J. Di Vesta, Ph.D. (Cornell) *Professor of Education and Psychology*
Joseph L. French, Ed.D. (Nebraska) *Professor of Special Education and Educational Psychology*
Paul A. Games, Ph.D. (Iowa) *Professor of Educational Psychology*
Robert L. Hale, Ph.D. (Nebraska) *Associate Professor of Education*
Edmond Marks, Ph.D. (Penn State) *Senior Research Associate; Affiliate Associate Professor of Educational Psychology*
Harold E. Mitzel, Ph.D. (Minnesota) *Professor of Psychology and Education*
Dennis M. Roberts, Ed.D. (Florida State) *Associate Professor of Educational Psychology*
Lita L. Schwartz, Ph.D. (Bryn Mawr) *Professor of Educational Psychology*
Robert Seibel, Ph.D. (Iowa) *Associate Professor of Psychology and Educational Psychology*

Associate Member of the Graduate Faculty
Henry T. Clark, Ph.D. (Columbia) *Assistant Professor of Education*

Graduate work is offered in the general field of educational psychology. Students may specialize and do research in one of the following areas: (1) human learning and memory as applied to instruction and education; (2) educational and psychological measurement; (3) statistics and research design as applied to education; and (4) the evaluation of educational programs. Special facilities available to students include rooms for conducting research projects and a closed-circuit television studio used for both research and instruction. Other facilities available to students majoring in Educational Psychol-

ogy are the Nursery School, the Psychology Clinic, the Reading Center, the Center for Educational Diagnosis and Remediation, the Division of Instructional Services, and the Speech and Hearing Clinic. The Computation Center, with several computer systems, is available for use in graduate student research. A microcomputer laboratory for students is located near their offices.

Admission Requirements

Applicants are invited to submit scores from the Graduate Record Examination (GRE). Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin*.

Students with a 3.00 junior-senior average and a broad undergraduate background, including some college mathematics, will be considered for admission. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests. Applicants with a master's degree will be required to show more than minimum success in graduate study, including at least one-half of their graduate credits of A quality. The best-qualified applicants will be accepted up to the number of spaces that are available for new students.

Master's Degree Requirements

There are two options in the master's program. A thesis option is available in any of the four areas, and the M.S. without thesis may be taken in learning or evaluation by teachers, counselors, administrators, parents, and others concerned with intervention strategies or evaluation of educational programs. The M.S. with thesis is required for Ph.D. candidates. Other areas of study related to educational psychology, such as counseling and guidance, clinical psychology, school psychology, and special education, are offered in other departments of the University. The following courses, or their equivalents taken within the last five years, should be represented in the student's program prior to the evaluation for the M.S. degree and Ph.D. candidacy: EDPSY 406, 421, 450, 475, and at least one 3-credit course in psychology from the biological bases of behavior, social bases of behavior, and individual differences.

Doctoral Degree Requirements

Doctoral degree requirements include a major emphasis in one of the four areas of educational psychology with minor emphasis in one other related area. The doctoral program of study includes those courses specified for a master's program and at least one course in educational or philosophical foundations. In lieu of the foreign language requirement for the Ph.D. degree, students are expected to present to the committee a statement of objectives and goals and a plan of the academic and nonacademic work to be undertaken in achieving these goals. Within the context of the above, the students are expected to incorporate relevant experiences which are now part of the language and communication requirements, whether in course work, research, or teaching, in order to increase their effectiveness as educational psychologists.

Student Aid

Graduate assistantships available to students in this program and other forms of student aid are described in the STUDENT AID section of the *Graduate Bulletin*.

EDUCATIONAL PSYCHOLOGY (EDPSY)

400. Introduction to Statistics in Educational Research (3)
406. Applied Statistical Inference for the Behavioral Sciences (3)
420. (SPLED 420) The Mentally Gifted (3)
421. Learning Processes in Relation to Educational Practices (3)
450. (PSY 450) Principles of Measurement (3)
451. Appraisal and Interpretation of Standardized Group Tests (2)
460. Principles of Program Evaluation (3)
475. Introduction to Educational Research (3)
496. Independent Studies (1-18)
497. Special Topics (1-9)

506. Advanced Techniques for Analyzing Educational Experiments (3) Analytical and experimental control considerations for designs involving nested and/or crossed subjects. Analysis of variance and multiple comparison via computers. Prerequisite: EDPSY 406 or PSY 415.

507. Multivariate Procedures in Educational Research (3) Introduction to matrix algebra, computer programming, multiple regression analysis, multiple and canonical correlation, multiple discriminant analysis, classification procedures, factor analysis. Prerequisite: EDPSY 406 or PSY 415.

512. Group Processes in the Classroom (2) Basic concepts and perspectives in the study of group processes; instructional group interaction; analysis of classroom behavior.

513. Individual and Group Differences (3) Description, causes, and interpretation of individual variation over the life span, with application to school and institutional practices. Prerequisite: EDPSY 400 or 450.

519. Psychological Foundations for College Teaching (3) Psychological, sociological, and organizational variables which influence instruction in colleges. For students planning teaching careers in colleges or similar settings.

520. (SPLED 520) Problems in the Education of the Mentally Gifted (2-4) Analysis of educational needs of the mentally gifted; curriculum construction and curricular materials. Prerequisites: EDPSY (SPLED) 420; teaching experience.

523. Concept Learning and Problem Solving (3-4) Theoretical-empirical trends in concept learning, problem solving, and creativity related to instructional psychology. Prerequisite: EDPSY 421.

524. Theories of Learning and Instruction (3) Study of major classical theories of learning and recent developments in learning and instructional theory. Prerequisite: EDPSY 421.

526. (RCLED 526) The Psychology of Reading (3) Psychological principles underlying the process of reading and comprehending, with application to instruction. Prerequisite: EDPSY 421.

527. Psychology of Adults as Learners (3) Psychological principles related to learning by adults, with application to instruction and other educational practices. Prerequisite: EDPSY 421.

528. Instructional Psychology (3) Application to instructional design of current developments in research on human development, information processing, learning strategies, memory structures, instructional processes. Prerequisite: EDPSY 421.

550. Design and Construction of Psychological Measures (3) Lecture-practicum involving planning, construction, administration, and analysis of a psychological test; lectures stress construct validity, item analysis, and predictive validity. Prerequisite: EDPSY 450.

554. Theories of Psychological Measurement (3) Basic true-score and error models; their extensions to test reliability and test validity; problems of item analysis and weighting. Prerequisite: EDPSY 450.

560. Contemporary Issues in the Evaluation of Educational Programs (3) Practical and theoretical issues in the planning, execution, and interpretation of program evaluations. Prerequisites: EDPSY 450, 460.

575. Seminar in Educational Psychology (3-9) A seminar dealing with specific topics in educational psychology. Open to advanced students in the behavioral sciences.

596. Individual Studies (1-9)

597. Special Topics (1-9)

602. Supervised Experience in College Teaching (1-3 per semester, maximum of 6)

EDUCATIONAL THEORY AND POLICY (EDTHP)

YOSHIMITSU TAKEI, *In Charge of Graduate Programs in Educational Theory and Policy*
320 Rackley Building
814-865-1488

Degrees Conferred: Ph.D., M.A.

Senior Members of the Graduate Faculty
Joseph V. Alessandro, D.Ed. (Penn State) *Professor of Education*
John Hardin Best, Ph.D. (North Carolina) *Professor of Education*
Henry C. Johnson, Jr., Ph.D. (Illinois) *Professor of Education*
Yoshimitsu Takei, Ph.D. (California) *Associate Professor of Education and Sociology*
Marylee C. Taylor, Ph.D. (Harvard) *Associate Professor of Sociology; Associate Professor of Education*

Associate Members of the Graduate Faculty
Francis R. McKenna, Ph.D. (Michigan) *Associate Professor of Education*
Madhu S. Prakash, Ph.D. (Syracuse) *Associate Professor of Education*

The master's and doctoral programs in Educational Theory and Policy are designed primarily to prepare persons for careers in education policy development and analysis. Students in the program may choose to emphasize policy development and analysis either in the United States or in terms of a comparative and international perspective. Individualized multidisciplinary programs of study in the foundation areas of education (history, philosophy, sociology, and comparative/international) and in the social sciences, management sciences, and/or humanities will be designed jointly by the student and the program faculty. Those who wish can qualify to receive certificates as international education development planning specialists or human resource development international planning specialists while engaged in their respective programs of study. It is anticipated that graduates will find employment in state departments of education, ministries of education, federal and international education agencies, academic institutions, and various professional associations.

Admission Requirements
Scores from the Graduate Record Examination (GRE) or from the Miller Analogies Test (MAT) are required for admission. At the discretion of a graduate program, a student may be admitted provisionally for graduate study in a program without these scores. Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin*.

The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Students with a 2.75 grade-point average will be considered for admission to the master's program, and with a 3.50 grade-point average at the master's level for the Ph.D. program. Exceptions to the minimum grade-point average may be made for students with special backgrounds, abilities, and interests.

Master's Degree Requirements
Candidates who seek an M.A. in Educational Theory and Policy shall complete programs that will include studies in social theory, policy, and planning or in the social sciences or humanities. A thesis is required.

Doctoral Degree Requirements
Candidates who seek a Ph.D. in Educational Theory and Policy shall complete programs that will include studies in social theory, policy, and planning, or in the social sciences or humanities.

All doctoral students must pass a written and oral candidacy examination after nine to eighteen hours of study.

Candidates for the Ph.D. degree are required to complete a minimum of two consecutive semesters in residence during an academic year.

The communication and foreign language requirements for the Ph.D. degree may be satisfied by options selected from foreign languages, statistics, computer science, logic, or other research methodologies deemed acceptable by the candidate's doctoral committee.

At the end of the program of study, each student must take a written comprehensive examination which will cover the student's major areas of study.

Other Relevant Information

Upon admission, each student will be assigned to a faculty adviser whose specialization best coincides with the student's background or academic interest. For the master's degree, the adviser and student together will plan the program of study. For doctoral students, the adviser and student will plan the early aspects of study, but an interdisciplinary committee will be formed, soon after the student is admitted to candidacy, to supervise completion of a program of study.

Student Aid

Graduate assistantships available to students in this program and other forms of student aid are described in the STUDENT AID section of the *Graduate Bulletin*.

EDUCATIONAL THEORY AND POLICY (EDTHP)

401. Introduction to Comparative Education (3)
402. Global Education (3)
403. Education in Socialist Societies (3)
404. Education in Africa (3)
405. Education in Asia (3)
406. Education in Europe (3)
407. Education in Latin America and the Caribbean (3)
408. Education in the Middle East (3)
411. Ethnic Minorities and Schools in the United States (3)
412. Education and the Status of Women (3)
415. (ANTH 415) Anthropology of Education (3)
416. (SOC 416) Sociology of Education (3)
430. History of Education in the United States (3)
440. Introduction to Philosophy of Education (3)
441. Education, Schooling, and Values (3)
496. Independent Studies (1-18)
497. Special Topics (1-9)

500. Proseminar in Educational Theory and Policy (1) An introduction to disciplinary and interdisciplinary studies in educational theory and policy.

501. Education in Developing Countries (3) The meaning of development and the role of education in the development process: theories, agents, trends, and case studies.

502. (EDADM 502) Educational Planning Techniques in Developing Countries, Part I (3) The introduction of systematic analysis, methodologies, and analytical techniques of education programs and projects to aid decision making in educational planning.

503. (EDADM 503) Educational Planning Techniques in Developing Countries, Part II (3) The application of systematic analysis to relevant educational planning cases that illustrate alternate solutions to particular problems of developing countries. Prerequisite: EDTHP (EDADM) 502.

504. Rural Education in Developing Nations (3) Analysis of the rural societies, education, and change in the rural sector of developing nations.

505. Nationality Policy and Education (3) Education and national integration; problems of cultural dominance in multinational states.

511. Education and Political Socialization (3) An examination of the studies which examine the function of schools in socializing the young for adult political roles.

512. Education and the Social Structure (3) An examination of the relationships between educational opportunities and social structure.

514. Social Change, Cultural Dynamics, and Education (3) The role of the school in promoting either social change or stability.

518. Analysis of U.S. Educational Policy (3) The interaction between educational theory and social structure, focusing on the role of practicing intellectuals in contemporary institutional settings.

530. The Development of the American School (3) American schooling critically examined institutionally from an historical perspective in social-cultural context. Emphasis on theories of interpretation and change.

531. Studies in Western Educational Thought to 1500 (3) General review and critical examination of selected Western educational ideas and movements from pre-Classical, Classical, Medieval, and early Renaissance periods.

533. Social History and Education Policy (3) Historical study of social dimensions in the formation of education policy.

536. Studies in Educational Thought (3) Studies in the historical development of educational theory.

537. History of American Indian Education Policy (3) Focusing on the relationship between American Indians and the United States, this course examines historical and contemporary federal education policy.

540. Dewey and the Pragmatic-Instrumentalist Educational Tradition (3) Critical examination of John Dewey's educational thought in the context of pragmatic philosophy and progressivism in American education.

541. Contemporary Philosophies of Education (3) Educational theory and practice in relation to contemporary movements in philosophy.

550. Seminar in American Indian Education (1-9) Analysis of issues of contemporary interest in American Indian education.

596. Individual Studies (1-9)

597. Special Topics (1-9)

ELECTRICAL ENGINEERING (E E)

KARL S. KUNZ, *Head of the Department*
129 Electrical Engineering East
814-865-7667

Degrees Conferred: Ph.D., M.S.

Senior Members of the Graduate Faculty
William S. Adams, Ph.D. (Penn State) *Professor of Electrical Engineering*
S. Ashok, Ph.D. (Rensselaer) *Professor of Engineering Science*
Nirmal K. Bose, Ph.D. (Syracuse) *Singer Professor of Signal Processing and Professor of Electrical Engineering*
John L. Brown, Jr., Ph.D. (Brown) *Professor of Electrical Engineering*
Lynn A. Carpenter, Ph.D. (Illinois) *Associate Professor of Electrical Engineering*
Lee D. Coraor, Ph.D. (Iowa) *Assistant Professor of Electrical Engineering*
Leslie E. Cross, Ph.D. (Leeds) *Professor of Electrical Engineering*
Mukunda B. Das, Ph.D. (London), D.I.C. *Professor of Electrical Engineering*
George A. Etzweiler, Ph.D. (Penn State) *Associate Professor of Electrical Engineering*
Tse-Yun Feng, Ph.D. (Michigan) *Binder Professor of Computer Engineering*
Anthony J. Ferraro, Ph.D. (Penn State) *Professor of Electrical Engineering*
Steven J. Fonash, Ph.D. (Pennsylvania) *Professor of Engineering Science*
David B. Geselowitz, Ph.D. (Pennsylvania) *Professor of Bioengineering*
Gennady Sh. Gildenblatt, Ph.D. (Rensselaer) *Associate Professor of Electrical Engineering*
Dale M. Grimes, Ph.D. (Michigan) *Professor of Electrical Engineering*
Leslie C. Hale, Ph.D. (Carnegie Tech.) *Robert Noll Distinguished Professor of Electrical Engineering*
Rangachar Kasturi, Ph.D. (Texas Tech) *Associate Professor of Electrical Engineering*
Iam-Choon Khoo, Ph.D. (Malaya) *Professor of Electrical Engineering*
Karl S. Kunz, Ph.D. (New Mexico State) *Professor and Head of Electrical Engineering*
Hai-Sup Lee, Ph.D. (Penn State) *Professor of Electrical Engineering*
Kwang Y. Lee, Ph.D. (Michigan) *Associate Professor of Electrical Engineering*
Raymond Luebbers, Ph.D. (Ohio State) *Associate Professor of Electrical Engineering*
Amarendra Mahalanabis, Ph.D. (Calcutta) *Professor of Electrical Engineering*
George J. McMurtry, Ph.D. (Purdue) *Professor of Electrical Engineering*
John J. Metzner, Eng.Sc.D. (New York) *Professor of Computer Engineering*
John A. Mitchell, Ph.D. (Penn State) *Professor of Electrical Engineering*
John S. Nisbet, Ph.D. (Penn State) *Distinguished Alumni Professor of Electrical Engineering*
James W. Robinson, Ph.D. (Michigan) *Professor of Electrical Engineering*
William J. Ross, Ph.D. (New Zealand) *Professor of Electrical Engineering*

Jerzy Ruzyllo, Ph.D. (Technical University of Warsaw) *Associate Professor of Electrical Engineering*
Thomas A. Seliga, Ph.D. (Penn State) *Professor of Electrical Engineering*
Christopher R. Wronski, Ph.D. (Imperial College London) *Leonhard Professor of Microelectronic Devices and Materials*
David O. Yevick, Ph.D. (Princeton) *Associate Professor of Electrical Engineering*
Francis T. S. Yu, Ph.D. (Michigan) *Evan Pugh Professor of Electrical Engineering*

Associate Members of the Graduate Faculty
Kultegin Aydin, Ph.D. (Middle East Tech.) *Assistant Professor of Electrical Engineering*
Chung-Ho Chen, Ph.D. (Pennsylvania) *Assistant Professor of Electrical Engineering, King of Prussia Center*
Charles Croskey, Ph.D. (Penn State) *Research Associate*
Derald Cummings, Ph.D. (Penn State) *Associate Professor of Electrical Engineering*
Chitaranjan Das, Ph.D. (S.W. Louisiana) *Assistant Professor of Computer Engineering*
John P. DeBarber, Ph.D. (Penn State) *Professor of Electrical Engineering*
James F. Delansky, Ph.D. (Cornell) *Associate Professor of Electrical Engineering*
Ahmed K. Elmagarmid, Ph.D. (Ohio State) *Assistant Professor of Computer Engineering*
Paul T. Hulina, Ph.D. (Penn State) *Associate Professor of Electrical Engineering*
David Landis, Ph.D. (Penn State) *Assistant Professor of Electrical Engineering*
Woei Lin, Ph.D. (Texas) *Assistant Professor of Computer Engineering*
John D. Mathews, Ph.D. (Case Western Reserve) *Adjunct Assistant Professor of Electrical Engineering*
Richard A. Mollo, Ph.D. (Penn State) *Associate Professor of Electrical Engineering*
Simin H. Pakzad, Ph.D. (Oklahoma) *Assistant Professor of Computer Engineering*
David W. Russell, Ph.D. (Manchester) *Associate Professor of Electrical Engineering, King of Prussia Center*
Ronald Standler, Ph.D. (New Mexico Inst. of Mining and Tech.) *Associate Professor of Electrical Engineering*
Jack J. Stein, Dr.Eng.Sci. (NYU) *Associate Professor of Electrical Engineering*
Matthew J. Thazhuthaveetil, Ph.D. (Wisconsin) *Assistant Professor of Computer Engineering*
Ken Tomiyama, Ph.D. (UCLA) *Assistant Professor of Electrical Engineering*
Hector M. Valenzuela, Ph.D. (Pittsburgh) *Assistant Professor of Electrical Engineering*
Chih-Chung Yang, Ph.D. (Illinois) *Assistant Professor of Electrical Engineering*

The principal areas of graduate research are in ionospheric studies, solid state electronics, computers and digital systems, power systems, electromagnetics, digital signal processing, optical signal processing, communications, and automatic control. Course offerings support these research areas, as well as work in biomedical engineering, network and system theory, plasmas, and quantum electronics.

For information about areas of specialization, laboratory and research facilities, fellowships, assistantships, and other sources of financial assistance, write directly to the Department of Electrical Engineering, The Pennsylvania State University, University Park, PA 16802 or write specifically to the Bioengineering program.

Admission Requirements
Scores from the Graduate Record Examination (GRE) are required for admission. At the discretion of a graduate program, a student may be admitted provisionally for graduate study in a program without these scores. Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin*.

Admission to the M.S. Program: (1) Satisfactory completion of an undergraduate electrical engineering program at an accredited institution or the equivalent, or (2) satisfactory completion of an undergraduate physics program at Penn State or an equivalent institution, with a minor in electronics. Such applicants will take two undergraduate courses in addition to the specific course requirements listed below. There are also some restrictions on their electives.

Admission to the Ph.D. Program: (1) Satisfactory completion of the M.S. degree requirements in electrical engineering or a closely related field at Penn State or an equivalent institution, or (2) direct admission from the undergraduate program for highly qualified individuals.

Master's Degree Requirements
The Master of Science requirements include the general requirements of the Graduate School as listed under Master's Degree Requirements.

Specific Course Requirements: (1) Thesis option — 24 course credits, 6 thesis credits, and a satisfactory thesis; (2) Nonthesis option — 32 course credits, including a selection of three core and other 500-level courses; and a scholarly report.

Doctoral Degree Requirements

The Doctor of Philosophy requirements include the general requirements of the Graduate School as listed under Doctoral Degree Requirements.

Specific Requirements: The communication requirement is met by adequacy in the English language and computer programming. The candidacy examination consists of both written and oral parts, and the comprehensive examination is oral.

Other Relevant Information

Continuous registration is required for all graduate students until the thesis or engineering report is approved.

Students in this program may elect the dual-title program option in Operations Research for the Ph.D. and M.S. degrees (see p. 326).

Student Aid

In addition to the fellowships, traineeships, graduate assistantships, and other forms of financial aid described in the STUDENT AID section of the *Graduate Bulletin*, the following awards typically have been available to graduate students in this program:

G. T. E. Fellowships — Available to a graduate student in electrical engineering. U.S. citizenship is required. Stipend is $15,000 for twelve months.

Harris Corporation Fellowship — Available to a graduate student in electrical engineering. Stipend is $12,000 for twelve months.

Palmer Fellowship Supplement — Accrued interest supplements the stipend of a graduate assistant.

ELECTRICAL ENGINEERING (E E)

405. Electronic Instrumentation for Nonelectrical Engineers and Scientists (3)
406. Electrical Power Generation and Transmission (3)
411. Principles of Electromagnetic Fields (3)
412. Optical Fiber Communications (3)
413. Linear Network Analysis (3)
414. Principles and Applications of Lasers and Masers (3)
415. (CMPSC 415) Computer Systems Architecture (3)
417. System Theory (3)
418. Solid State Device Technology (3)
419. Solid State Devices (3)
420. Electro Optics — Introduction to Holography (3)
423. Fundamentals of Industrial Electronics (3)
424. Fundamentals of Electrical Design (3)
425. Symmetrical Components (3)
428. Linear Control Systems (3)
429. Introduction to Digital Control Systems (3)
432. UHF and Microwave Engineering (3)
438. Antenna Engineering (3)
439. Radiowave Propagation in Communications (3)
447. Digital Integrated Circuits (3)
448. Linear Electronic Design (3)
449. Digital Electronic Design (3)
450. Network Analysis (3)
453. Fundamentals of Digital Signal Processing (3)
455. An Introduction to Digital Image Processing (3)
458. Data Communication (3)
459. Introduction to Statistical Theory of Communications (3)
461. Fundamentals of Power System Stability (3)
470. Electronic Analog Computers (3)
471. Logical Design of Digital Systems (3)
472. Digital Systems (3)
473. Digital Systems Laboratory (3)
475. Introduction to Hybrid Computation (3)

477. Synthesis and Design of Electrical Systems (3)
490. (AERSP 490, NUC E 490) Introduction to Plasmas (3)
492. (AERSP 492, ASTRO 492) Space Astronomy and Introduction to Space Science (3)
494. Senior Thesis (1-9)
496. Independent Studies (1-18)
497. Special Topics (1-9)

511. Engineering Electromagnetics (3) Electromagnetic field theory fundamentals with application to transmission lines, waveguides, cavities, antennas, radar, and radio propagation. Prerequisite: E E 411.

519. Semiconductor Devices (3) Characteristics and limitations of bipolar transistors, diodes, transit time, and bulk-effect devices. Prerequisite: E E 419.

520. Electro Optics — Optical Information Processing (3) Coherent and incoherent optical information processing, synthetic aperture radar, complex spatial filtering, image synthesis, color image processing, applications. Prerequisite: E E 420.

522. Electro-Optics Laboratory (3) Basic concepts and fundamentals of light diffraction, optical signal processing, and holography. Prerequisite: E E 420.

524. Nonlinear Optics and Optical Electronics (3) Study of several advanced nonlinear optical phenomena, laser propagation, optical and optoelectronic devices, principles, and applications. Prerequisite: E E 414.

527. Linear Control Systems (3) Continuous and discrete-time linear control systems; state variable models; analytical design for deterministic and random inputs; time-varying systems stability. Prerequisites: E E 428 or M E 455; E E 417.

529. Optimal Control (3) Variational methods in control system design; classical calculus of variations, dynamic programming, maximum principle; optimal digital control systems; state estimation. Prerequisite: E E 527.

530. Adaptive and Learning Systems (3) Adaptive and learning control systems; system identification; performance indices; gradient, stochastic approximation, controlled random search methods; introduction to pattern recognition. Prerequisite: E E 527.

535. Engineering Analysis (3) Applications of mapping methods, series and integral representations to the solution of boundary-value problems in electrical engineering.

537. Numerical and Asymptotic Methods of Electromagnetics (3) Application of the geometrical theory of diffraction and method of moments to antenna and radar scattering problems in electrical engineering. Prerequisite: E E 511.

538. Antenna Engineering (3) In-depth studies of synthesis methods, aperture sources, broadband antennas, and signal-processing arrays. Prerequisite: E E 438.

540. (AERSP 540, NUC E 540) Theory of Plasma Waves (3) Solutions of the Boltzmann equation; waves in bounded and unbounded plasmas; radiation and scattering from plasmas. Prerequisite: E E (AERSP, NUC E) 490.

541. (NUC E 541) Plasma Theory (3) Advanced topics in kinetic theory, fluctuation theory, microinstability, and turbulence. Prerequisite: E E (AERSP, NUC E) 490.

546. Field-Effect Devices (3) The physical background, characteristics, and limitations of surface field-effect and junction field-effect devices and related structures. Prerequisite: E E 419.

547. Dielectric Devices (3) Applications of insulator physics and devices based on insulator properties. Prerequisite: E E 419.

548. Linear Integrated Circuits (3) Design of monolithic, thin-film, and hybrid linear integrated circuits; D.C., video, tuned, r.f., and microwave applications. Emphasis on reliability. Prerequisites: E E 418, 448.

550. Network Synthesis (3) Positive real functions, realizability conditions, synthesis of driving point immittances, synthesis of two-terminal pair networks, transfer function synthesis. Prerequisite: E E 450.

553. Applied Digital Signal Processing (3) Hardware implementation of signal processing algorithms; spectral estimation; speech and radar signal processing; VLSI design for signal processing. Prerequisite: E E 453.

555. Digital Image Processing II (3) Advanced treatment of image processing techniques; linear and nonlinear restoration; segmentation, feature description, symbolic representation; image understanding systems; computer projects. Prerequisite: E E 455.

559. (M E 559) Nonlinear Control and Stability (3) Design of nonlinear automatic control systems; phase-plane methods; describing functions; optimum switched systems; Liapunov stability; special topics in stability. Prerequisite: E E 417 or 428 or M E 455.

560. Stochastic Processes and Estimation (3) Review of probability theory and random variables; mathematical description of random signals; linear system response; Wiener, Kalman, and other filtering. Prerequisites: E E 459 or MATH 409.

561. Information Theory (3) Mathematical measurement of information; information transfer in discrete systems; redundancy, efficiency, and channel capacity; encoding systems. Prerequisite: E E 459 or MATH (STAT) 414.

562. Detection Theory (3) Detection decision theory, Bayes and Neyman-Pearson criteria, optimal receivers, classical estimation theory, signal-noise representations, optimum linear signal parameters estimation. Prerequisite: E E 560.

563. Signal Theory I (3) Requires familiarity with fundamentals of linear system theory and rudiments of Fourier analysis. Prerequisites: E E 352, 417.

565. Computer Analysis of Power Systems (3) Network matrix methods of power system analysis. Formulation and computer solution of short circuit, load flow, and transient stability problems. Prerequisites: CMPSC 201; E E 425 or 461.

569. Simulation of Biomedical Systems (3) Simulation of biological and medical systems on analog and digital computers; direct electrical analogs; modeling techniques. Prerequisites: E E 470, BIOL 101.

570. Advanced Electronic Analog Computers (3) Advanced techniques of analog computation and simulation; machine and problem errors; nonlinear differential equations. Prerequisite: E E 470.

571. Switching and Sequential Machine Theory (3) Advanced treatment of switching and machine theory, minimization of machines, state assignment, hazard analysis. Prerequisite: E E 472.

572. Digital System Design (3) Complete digital system design, including specification, internal organization, and realization. Discussion of interaction among digital systems and subsystems. Prerequisite: E E 472.

573. Fault Detection in Digital Circuits (3) Advanced treatment of fault detection, location, and redundancy techniques. Prerequisite: E E 472.

577. Integrated Circuit and System Design (3) Engineering design of large-scale integrated circuits, systems, and applications; study of advanced design techniques, architectures, and CAD methodologies. Prerequisite: E E 449.

578. Digital Integrated Circuit Evaluation Laboratory (3) Logic performance characterization, functional testing, fault analysis, and demonstration of student-designed, custom-integrated circuits. Prerequisite: E E 577.

580. Radio Waves and the Ionosphere (3) The magneto-ionic theory of ionospheric wave propagation; ray-optical approximations; determination of ionization profiles; full wave solutions; nonlinear and coupling effects. Prerequisite: E E 438 or PHYS 557.

581. Constitution of the Ionosphere (3) Properties of neutral and ionized atmosphere above 60 km; photochemical processes; solar, meteoric perturbations of the ionosphere; large-scale movements in ionization.

594. Research Projects (1-2) Supervision of individual research projects leading to M.S. papers. Written and oral reports are required.

596. Individual Studies (1-9)

597. Special Topics (1-9)

ENGINEERING MECHANICS (E MCH)

R. P. McNITT, *Head of the Department of Engineering Science and Mechanics*
227B Hammond Building
814-865-6661

Degrees Conferred: Ph.D. in Engineering Science and Mechanics, M.S., M.Eng.

Senior Members of the Graduate Faculty
Maurice F. Amateau, Ph.D. (Case Western Reserve) *Professor of Engineering Science and Mechanics*
S. Ashok, Ph.D. (Rensselaer) *Professor of Engineering Mechanics*
J. C. Conway, Ph.D. (Penn State) *Professor of Engineering Mechanics*
Stephen J. Fonash, Ph.D. (Pennsylvania) *Professor of Engineering Science*
H. Thomas Hahn, Ph.D. (Penn State) *Professor of Engineering Science and Mechanics*
S. I. Hayek, Dr.Eng.Sci. (Columbia) *Professor of Engineering Mechanics*
L. Raymond Hettche, Ph.D. (Carnegie-Mellon) *Professor of Engineering Research*
J. Kiusalaas, Ph.D. (Northwestern) *Professor of Engineering Mechanics*
P. M. Lenahan, Ph.D. (Illinois) *Professor of Engineering Science and Mechanics*
R. E. Llorens, Ph.D. (Penn State) *Professor of Engineering Mechanics*
R. P. McNitt, Ph.D. (Purdue) *Professor of Engineering Science and Mechanics*
R. Messier, Ph.D. (Penn State) *Associate Professor of Engineering Science and Mechanics*
V. H. Neubert, D.Eng. (Yale) *Professor of Engineering Mechanics*
R. N. Pangborn, Ph.D. (Rutgers) *Associate Professor of Engineering Mechanics*
R. A. Queeney, Ph.D. (Penn State) *Professor of Engineering Mechanics*
N. J. Salamon, Ph.D. (Northwestern) *Professor of Engineering Science and Mechanics*
M. G. Sharma, Ph.D. (Penn State) *Professor of Engineering Mechanics*
William Thompson, Jr., Ph.D. (Penn State) *Professor of Engineering Science*
Vasundara V. Varadan, Ph.D. (Illinois) *Professor of Engineering Science and Mechanics*
Vijay K. Varadan, Ph.D. (Northwestern) *Professor of Engineering Science and Mechanics*
Christopher R. Wronski, Ph.D. (Imperial College, London) *Leonhard Professor of Microelectronic Materials and Devices*
S. Y. Zamrik, Ph.D. (Penn State) *Professor of Engineering Mechanics*

Associate Members of the Graduate Faculty
R. Bhagat, Ph.D. (Indian Inst. of Tech.) *Research Associate*
Courtney B. Burroughs, Ph.D. (Catholic) *Research Associate*
Ram Kossowsky, Ph.D. (Pennsylvania) *Senior Research Associate, IRP*
Akhlesh Lakhtakia, Ph.D. (Utah) *Assistant Professor of Engineering Science and Mechanics*
Martin J. Pechersky, Ph.D. (Penn State) *Associate Professor of Engineering Science and Mechanics*
Andrew Pytel, Ph.D. (Penn State) *Professor of Engineering Mechanics*
Jean Landa Pytel, Ph.D. (Penn State) *Assistant Professor of Engineering Mechanics*
Clayton O. Ruud, Ph.D. (Denver) *Senior Research Associate*

Graduate programs in Engineering Mechanics emphasize fundamental knowledge and include research opportunities in theoretical and experimental mechanics, with a primary focus on the mechanics and physics of solids.

Graduate study is available in continuum mechanics, structural mechanics, dynamics, vibrations and acoustics, biomechanics, micromechanics, experimental mechanics, and characterization and utilization of materials. Thesis work in these areas is frequently directed toward specific applications of technological interest in biosystems, geosystems, energy production and distribution, materials engineering, and structural design.

Admission Requirements
Scores from the Graduate Record Examination (GRE) are not required for students holding baccalaureate degrees in engineering from accredited U.S. educational institutions. At the discretion of a graduate program, students may be admitted provisionally for graduate study in the program without these scores. Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin*.

The entering student must hold a bachelor's degree in engineering or science and have satisfactorily completed undergraduate courses in mechanics. Students with a 2.90 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum grade-point average may be made for students with special backgrounds, abilities, and interests.

Doctoral Degree Requirements

Doctoral candidates must pass a candidacy examination; satisfy a communications requirement by a course in technical writing; and pass a comprehensive examination.

Programs leading to a minor in Engineering Mechanics are available for doctoral students who seek to complement their studies in their major fields by acquiring a broader background in theoretical and experimental mechanics.

Other Relevant Information

Continuous registration is required for all students until the thesis or engineering report is approved.

Other course offerings of the department are listed under OTHER COURSES AND OPTIONS CARRYING GRADUATE CREDIT.

Student Aid

In addition to the fellowships, traineeships, graduate assistantships, and other forms of financial aid described in the STUDENT AID section of the *Graduate Bulletin,* the following awards typically have been available to graduate students in this program:

W. S. Elliott Fellowship — Available to a graduate student who is a graduate of Penn State and is interested in engineering research; stipend variable. Apply to Office of the Dean, College of Engineering, 101 Hammond Building.

Tau Beta Pi Fellowship — Open to any member of Tau Beta Pi, the engineering honor society, for a year of advanced study. Up to twenty-four cash awards are available. Applications and information can be obtained from the chapter officers, 212 Sackett Building. Application deadline is late January.

Theodore Holden Thomas, Jr., Memorial Scholarship — Available to undergraduate or graduate students who display outstanding academic ability and have enrolled in the Department of Engineering Science and Mechanics. Apply to the Department of Engineering Science and Mechanics, 227 Hammond Building. Deadline is February 1.

ENGINEERING MECHANICS (E MCH)

400. Advanced Strength of Materials and Design (3) *Hu*
401. Design and Synthesis in Vibrations (3)
402. Applied and Experimental Stress Analysis (3) *Conway*
403. Strength Design in Materials and Structures (4) *Queeney*
407. Computer Methods in Engineering Design (3) *Kiusalaas*
408. Elasticity and Engineering Applications (3) *Kiusalaas*
409. Advanced Mechanics (3)
410. Mechanics of Space Flight (3)
412. Experimental Methods in Vibrations (3) *Neubert*
415. Fracture Mechanics (3) *Queeney*
416H. Failure and Failure Analysis of Solids (3)
440. (MATSC 440) Nondestructive Evaluation of Flaws (3)
446. Mechanics of Viscoelastic Materials (3) *Sharma*
461. (M E 461) Applied Finite Element Analysis (3)
471. Engineering Composite Materials (3)
496. Independent Studies (1-18)
497. Special Topics (1-9)

500. Advanced Mechanics of Materials (3-6) Strain energy methods; special problems in bending and torsion; curved bars, beams on elastic foundations; thick-walled cylinders, shrink-fit assemblies, and rotating discs; thin-walled pressure vessels; bending of thin plates; buckling of bars and plates. Prerequisite: E MCH 013. *Zamrik*

506. Experimental Stress Analysis (3) Experimental methods of stress determination, including photoelasticity, stress coat, and electric strain gauge techniques; stress analogies; strain rosettes for combined stress determinations. Prerequisite: E MCH 408 or 507. *Conway*

507. Theory of Elasticity and Applications (3) Equations of equilibrium and compatibility; stresses and strains in beams, curved members, rotating discs, thick cylinders, torsion and structural members. Prerequisite: E MCH 013.

509. Theory of Plates and Shells (3) Bending and buckling of plates; elastic foundations; deformation of shells, multilayer shells, stress and stability analysis, weight optimization, application problems. Prerequisite: E MCH 013.

514. Engineering Mechanics Seminar (1 per semester) Current literature and special problems in engineering mechanics.

516. Mathematical Theory of Elasticity (3) Fundamental equations and problems of elasticity theory; uniqueness theorems and variational principles; methods of stress functions and displacement potential; applications. Prerequisite: E MCH 540. *Hayek*

520. Advanced Dynamics (3) Dynamics of a particle and of rigid bodies; Newtonian equations in moving coordinate systems; Lagrange's and Hamilton's equations of motion; special problems in vibrations and dynamics. Prerequisites: E MCH 012, MATH 411. *Pytel*

521. Stress Waves in Solids (3) Theoretical fundamentals, classic experiments; recent advances, including scabbing applications, plastic waves, penetration mechanics, impact and numerical methods. Prerequisites: E MCH 012; MATH 412 or E MCH 524A and 524B.

522. Theory of Vibrations (3) Mathematical theory of vibrating systems; damping phenomena; forced vibrations; analogy betwen mechanical and electrical vibrations; transverse and torsional oscillation of shafts; vibration of strings, beams, membranes, and plates. Prerequisites: E MCH 013, MATH 411. *Neubert*

524. Mathematical Methods in Engineering (3 per unit) *Hayek and Thompson*

Unit A (3) Application of special functions, orthogonal series, and boundary-value problems to problems in mechanics and other engineering fields. Prerequisite: MATH 250.

Unit B (3) Solution techniques for boundary-value problems in curvilinear coordinates, integral transforms; Green's functions, potentials, application to diffusion, vibration, wave propagation. Prerequisite: E MCH 524A or E SC 404H.

Unit C (3) Green's functions applied to problems in potentials, vibration, wave propagation, and diffusion, with special emphasis on asymptotic methods. Prerequisite: E MCH 524B or E SC 404H.

525. Structural Vibration and Radiation (3) Vibration response, propagation, transmission, and reflection in elastic structures; internal and external damping; fluid loading; impedance discontinuities; acoustic radiation.

527. Structural Dynamics (3) Dynamic behavior of structural systems; normal modes; input spectra; finite element representation of frameworks, plates, and shells; impedance; elastic-plastic response. Prerequisite: E MCH 401 or 522. *Neubert*

528. Experimental Methods in Vibrations (3) Investigation of one or more degrees of freedom, free and forced mechanical vibrations, vibration properties of materials, nondestructive testing. Prerequisite: E MCH 401 or 522. *Neubert*

530. Mechanical Behavior of Materials (3) Engineering materials mechanical responses; stress/strain in service context of temperature, time, chemical environment; mechanical testing characterization; design applications.

531. Theory of Plasticity and Applications (3) Yield condition; plastic stress-strain relations; theory of slip-line fields; applications to bending, torsion, axially symmetric bodies, metal processing. Prerequisite: E MCH 507.

532. Fracture Mechanics (3) Stress analysis of cracks; stable and unstable crack growth in structures and materials; materials fracture resistance. Prerequisite: E MCH 500.

534. (METAL 534) Micromechanisms of Fracture (3) Mechanisms of fracture and their relationship to loading conditions, environment, flow behavior, processing history, and microstructure. Prerequisites: E SC 414H, METAL 406.

535. (METAL 535) Crystal Defects and Mechanical Response (3) Deformation of crystalline solids containing point, line, and interfacial defects; elastic and plastic responses over a range of temperatures and strain rates. Prerequisite: E SC 414H or METAL 406.

540. Introduction to Continuum Mechanics (3) Algebra and analysis of tensors; balance equations of classical physics; the linear theories of continuum mechanics. *Hayek*

546. Theory of Viscoelasticity and Applications (3) Linear and nonlinear viscoelastic theories; generalized isotropic and anisotropic viscoelastic stress-strain relations. Prerequisite: E MCH 507. *Sharma*

550. Variational and Energy Methods in Engineering (3) Application of variational calculus and Hamilton's principle to various conservative and nonconservative systems; closed form and approximate technique. Prerequisite: MATH 251.

552. (BIOE 552, I E 552) Mechanics of the Musculoskeletal System (3) Structure and biomechanics of bone, cartilage, and skeletal muscle; dynamics and control of musculoskeletal system models. Prerequisite: consent of program. Prerequisite or concurrent: BIOL 472.

560. Finite Element Analysis (3) General theory; application to statics and dynamics of solids, structures, fluids, and heat flow; use of existing computer codes. Prerequisites: CMPSC 201, E MCH 013.

562. (AG E 562) Boundary Element Analysis (3) Numerical solution of boundary value problems using fundamental solutions; application to problems in potential theory, diffusion, and elastostatics. Prerequisite: AG E 513 or E MCH 461 or E MCH 560.

563. (M E 563) Nonlinear Finite Elements (3) Advanced theory of semidiscrete formulations for continua and structures; emphasizes dynamic and nonlinear problems. Prerequisite: E MCH 461 or E MCH 560 or AG E 513.

570. Random Vibrations in Structural Mechanics (3) Probability theory applied to random vibrations of linear and nonlinear systems; excitation by ground motion, turbulence, and noise; acoustic damping. Prerequisite: AERSP 411 or E MCH 401 or 522. *Neubert*

596. Individual Studies (1-9)

597. Special Topics (1-9)

ENGINEERING SCIENCE (E SC)

R. P. McNITT, *Head of the Department of Engineering Science and Mechanics*
227B Hammond Building
814-865-6661

Degree Conferred: Ph.D. in Engineering Science and Mechanics, M.S.

Senior Members of the Graduate Faculty

Maurice F. Amateau, Ph.D. (Case Western Reserve) *Professor of Engineering Science and Mechanics*
S. Ashok, Ph.D. (Rensselaer) *Professor of Engineering Mechanics*
J. C. Conway, Ph.D. (Penn State) *Professor of Engineering Mechanics*
Stephen J. Fonash, Ph.D. (Pennsylvania) *Professor of Engineering Science*
H. Thomas Hahn, Ph.D. (Penn State) *Professor of Engineering Science and Mechanics*
S. I. Hayek, Dr.Eng.Sci. (Columbia) *Professor of Engineering Mechanics*
L. Raymond Hettche, Ph.D. (Carnegie-Mellon) *Professor of Engineering Research*
J. Kiusalaas, Ph.D. (Northwestern) *Professor of Engineering Mechanics*
P. M. Lenahan, Ph.D. (Illinois) *Professor of Engineering Science and Mechanics*
R. E. Llorens, Ph.D. (Penn State) *Professor of Engineering Mechanics*
R. P. McNitt, Ph.D. (Purdue) *Professor of Engineering Science and Mechanics*
R. Messier, Ph.D. (Penn State) *Associate Professor of Engineering Science and Mechanics*
V. H. Neubert, D.Eng. (Yale) *Professor of Engineering Mechanics*
R. N. Pangborn, Ph.D. (Rutgers) *Associate Professor of Engineering Mechanics*
R. A. Queeney, Ph.D. (Penn State) *Professor of Engineering Mechanics*
N. J. Salamon, Ph.D. (Northwestern) *Professor of Engineering Science and Mechanics*
M. G. Sharma, Ph.D. (Penn State) *Professor of Engineering Mechanics*
William Thompson, Jr., Ph.D. (Penn State) *Professor of Engineering Science*
Vasundara V. Varadan, Ph.D. (Illinois) *Professor of Engineering Science and Mechanics*
Vijay K. Varadan, Ph.D. (Northwestern) *Professor of Engineering Science and Mechanics*
Christopher R. Wronski, Ph.D. (Imperial College, London) *Leonhard Professor of Microelectronic Materials and Devices*
S. Y. Zamrik, Ph.D. (Penn State) *Professor of Engineering Mechanics*

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R. Bhagat, Ph.D. (Indian Inst. of Tech.) *Research Associate.*
Courtney B. Burroughs, Ph.D. (Catholic) *Research Associate*
Ram Kossowsky, Ph.D. (Pennsylvania) *Senior Research Associate, IRP*
Akhlesh Lakhtakia, Ph.D. (Utah) *Assistant Professor of Engineering Science and Mechanics*
Martin J. Pechersky, Ph.D. (Penn State) *Associate Professor of Engineering Science and Mechanics*
Andrew Pytel, Ph.D. (Penn State) *Professor of Engineering Mechanics*
Jean Landa Pytel, Ph.D. (Penn State) *Assistant Professor of Engineering Mechanics*
Clayton O. Ruud, Ph.D. (Denver) *Senior Research Associate*

This program is characterized by strong components in engineering analysis, the basic sciences, and areas of emerging technological importance. The program is interdisciplinary in structure with sufficient flexibility to allow a student to specialize in any of a variety of disciplines according to his or her professional objectives.

Admission Requirements
Scores from the Graduate Record Examination (GRE), or from a comparable substitute examination accepted by a graduate program and authorized by the dean of the Graduate School, are required for admission. At the discretion of a graduate program, a student may be admitted provisionally for graduate study in a program without these scores. Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin.*

Admission to the program requires a bachelor's degree in engineering or science from an accredited institution, with a junior-senior grade-point average of at least 2.50. The best-qualified applicants will be accepted up to the number of spaces that are available for new students.

Degree Requirements
The basic requirements of course work by subject area are as follows:

Engineering Analysis	— 6 credits
Materials	— 6 credits
Basic Sciences	— 6 credits
Engineering Sciences	— 6 credits

Within these guidelines, work in the listed areas may be arranged in consultation with the adviser to constitute a program of study to accommodate the objectives of the student, and it is expected that courses outside the department may constitute part of the content in the engineering sciences.

Doctoral candidates must pass a candidacy examination, satisfy a communications requirement by a course in technical writing, and pass a comprehensive examination.

Programs leading to a minor in Engineering Science are available for doctoral students who want to complement their studies in their major fields by acquiring a broader background in theoretical and experimental mechanics.

A thesis is required for the M.S. degree as part of the 30 credits required in the program.

Continuous registration is required for all graduate students until the thesis is approved.

Other Relevant Information
This program should be distinguished from the graduate programs in Engineering Science at Penn State-Behrend, Penn State Harrisburg, and King of Prussia, which offer the M.Eng. degree.

Student Aid
In addition to the fellowships, traineeships, graduate assistantships, and other forms of financial aid described in the STUDENT AID section of the *Graduate Bulletin,* the following awards typically have been available to graduate students in this program:

W. S. Elliott Fellowship — Available to a graduate student who is a graduate of Penn State and is interested in engineering research; stipend variable. Apply to Office of the Dean, College of Engineering, 101 Hammond Building.

Tau Beta Pi Fellowship — Open to any member of Tau Beta Pi, the engineering honor society, for a year of advanced study. Up to twenty-four cash awards are available. Applications and information can be obtained from the chapter officers, 212 Sackett Building. Application deadline is late January.

THEODORE HOLDEN THOMAS, JR., MEMORIAL SCHOLARSHIP — Available to undergraduate or graduate students who display outstanding academic ability and have enrolled in the Department of Engineering Science and Mechanics. Apply to the Department of Engineering Science and Mechanics, 227 Hammond Building. Deadline is February 1.

ENGINEERING SCIENCE (E SC)

GEORGE J. McMURTRY, *Associate Dean for Instruction, College of Engineering*
101 Hammond Building
(814) 865-2151

PENN STATE ERIE, THE BEHREND COLLEGE — Anthony A. Salvia, *Director of Program*

PENN STATE GREAT VALLEY — Jack Stein, *Chair of Engineering Programs Committee*

PENN STATE HARRISBURG, THE CAPITAL COLLEGE — Lawrence A. Ezard, *Director of Program*

Degree Conferred: M.Eng.

PENN STATE-BEHREND

Associate Members of the Graduate Faculty
Richard A. Bollinger, Ph.D. (Pittsburgh) *Associate Professor of Mathematics*
Anthony A. Salvia, Ph.D. (Case Western Reserve) *Associate Professor of Industrial Engineering*

PENN STATE GREAT VALLEY

Senior Members of the Graduate Faculty
Richard E. Llorens, Ph.D. (Penn State) *Professor of Engineering Mechanics*

Associate Members of the Graduate Faculty
Robert L. Duncan, M.A. (Penn State) *Associate Professor of Mathematics*
Eugene Kozik, Ph.D. (Pittsburgh) *Associate Professor of Industrial Engineering*
Jack Stein, Ph.D. (NYU) *Associate Professor of Electrical Engineering*

PENN STATE HARRISBURG

Senior Members of the Graduate Faculty
Barnard H. Bissinger, Ph.D. (Cornell) *Professor of Mathematics*
Charles A. Cole, Ph.D. (Rutgers) *Professor of Engineering*
Sabir H. M. Dahir, Ph.D. (North Carolina State) *Professor of Engineering*
George H. Grenier, Ph.D. (Montana) *Professor of Engineering*
Vedula N. Murty, Ph.D. (Purdue) *Professor of Mathematics*

Associate Members of the Graduate Faculty
Rita G. Blatt, Ph.D. (Pittsburgh) *Associate Professor of Chemistry*
Lawrence A. Ezard, Ph.D. (Pennsylvania) *Associate Professor of Engineering*
Jefferson S. Hartzler, Ph.D. (Penn State) *Associate Professor of Mathematics*
William R. Miller, Ph.D. (Delaware) *Associate Professor of Engineering*
Winston A. Richards, Ph.D. (Western Ontario) *Associate Professor of Mathematics*
M. Susan Richman, Ph.D. (Aberdeen) *Associate Professor of Mathematics*
Roger W. Schiller, M.S. (Kansas) *Associate Professor of Engineering*
Jerry F. Shoup, Ph.D. (Penn State) *Associate Professor of Engineering*
Clifford H. Wagner, Ph.D. (SUNY-Albany) *Assistant Professor of Mathematics*
Scott E. Walters, Ph.D. (Tennessee) *Assistant Professor of Chemistry*
William A. Welsh, Ph.D. (Illinois) *Associate Professor of Engineering*

A program leading to the degree of Master of Engineering with a major in Engineering Science is offered at Penn State-Behrend, Penn State Great Valley, and Penn State Harrisburg. The program is designed to provide a broad, advanced education in the engineering sciences with some specialization permitted in the area of the student's major interest. It is offered specifically to permit practicing engineers to pursue advanced studies through evening classes while in full-time employment in industry in the area. Courses offered for the program are all established and authorized by the resident departments at the University Park Campus.

This program should be distinguished from the graduate program in Engineering Science at University Park, which offers the M.S. degree.

Admission Requirements

Scores from the Graduate Record Examination (GRE) are not required for students holding baccalaureate degrees in engineering from accredited U.S. educational institutions. At the discretion of a graduate program, students may be admitted provisionally for graduate study in a program without these scores. Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin.*

Students may be admitted to the program from a wide variety of disciplines. Students applying for admission are expected to have completed the following core courses: (1) physics through modern physics; (2) mathematics through differential equations; (3) one course in engineering thermodynamics; (4) one course in electrical circuits; and (5) basic courses in engineering statics and dynamics. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

Degree Requirements

The credit requirements in this major will be satisfied by an appropriate combination of core courses and elective courses. The core courses include offerings in mathematics and in several branches of engineering that have been selected because of their general character and breadth of applicability to all fields of engineering.

A minimum of 30 credits is required, of which at least 12 must be at the 500 level. A scholarly written report is also required. Three of the above credits may be applied to this report.

Other Relevant Information

More details regarding admission requirements are available from the directors of the graduate centers offering the program.

Student Aid

In addition to the fellowships, traineeships, graduate assistantships, and other forms of financial aid described in the STUDENT AID section of the *Graduate Bulletin,* the following awards typically have been available to graduate students in this program:

W. S. Elliott Fellowship — Available to a graduate student who is a graduate of Penn State and is interested in engineering research; stipend variable. Apply to Office of the Dean, College of Engineering, 101 Hammond Building.

ENGINEERING SCIENCE (E SC)

400H. Electromagnetic Fields (3)
404H. Analysis in Engineering Science I, Honors (3)
405H. Engineering Applications of Field Theory (3)
406H. Analysis in Engineering Science II, Honors (3)
407H. Computer Methods in Engineering Science, Honors (3)
410H. Senior Design Project, Honors (3)
411H. Senior Design Project, Honors (4)
414H. Elements of Material Science (3)
445. Semiconductor Optoelectronic Devices (3)
494. Senior Thesis (1-9)
496. Independent Studies (1-18)
497. Special Topics (1-9)

501. Solid State Energy Conversion (3) Principles of solid state energy conversion and their utilization in engineering devices. Emphasis on current research and development efforts. Prerequisite: E E 419 or PHYS 412.

502. Semiconductor Heterojunctions and Applications (3) Theory, fabrication techniques, and electronic applications of semiconductor heterojunctions, including metal-semiconductor and electrolyte-semiconductor junctions. Prerequisite: E SC 314 or 414.

511. Engineering Materials for Energy Conversion and Storage (3) This course treats engineering materials and systems employed in conventional and unconventional direct energy conversion and energy storage.

536. Wave Propagation and Scattering (4) Survey of analytical and numerical methods for solving acoustic, electromagnetic, and elastic wave propagation and scattering problems. Prerequisite: E MCH 524A or 524B.

537. Multiple Scattering Theories and Dynamic Properties of Composite Materials (3) Acoustic, dielectric, elastic dynamic properties; periodic, random composites; wave propagation and scattering; attenuation, dispersion; superviscous absorption; sonar, optical, ultrasonic applications.

596. Individual Studies (1-9)

597. Special Topics (1-9)

Note: *Other departmental courses are listed under ENGINEERING MECHANICS.*

ENGLISH (ENGL)

JAMES L. W. WEST III, *Director of Graduate Studies*
144S Burrowes Building
814-863-3069

Degrees Conferred: Ph.D., M.A., M.F.A., M.Ed.

Senior Members of the Graduate Faculty
Judd B. Arnold, Ph.D. (Connecticut) *Associate Professor of English*
John Balaban, M.A. (Harvard) *Professor of English*
Michael H. Begnal, Ph.D. (Washington) *Professor of English and Comparative Literature*
Elmer W. Borklund, Ph.D. (Chicago) *Professor of English*
Christopher Clausen, Ph.D. (Queen's College, Canada) *Professor of English*
Robert C. S. Downs, M.F.A. (Iowa) *Professor of English*
Caroline D. Eckhardt, Ph.D. (Michigan) *Professor of English and Comparative Literature*
Wendell V. Harris, Ph.D. (Wisconsin) *Professor of English*
John T. Harwood, Ph.D. (Nebraska) *Associate Professor of English*
Kathryn Hume, Ph.D. (Pennsylvania) *Associate Professor of English*
Robert D. Hume, Ph.D. (Pennsylvania) *Professor of English*
Nicholas A. Joukovsky, D.Phil. (Oxford) *Associate Professor of English*
Michael Kiernan, Ph.D. (Harvard) *Associate Professor of English*
Robert E. Lougy, Ph.D. (California) *Associate Professor of English*
Charles W. Mann, Jr., M.L.S. (Rutgers) *Professor of English*
Joseph G. Price, Ph.D. (Bryn Mawr) *Professor of English*
Audrey T. Rodgers, Ph.D. (Penn State) *Associate Professor of English*
Thomas H. Rogers, Ph.D. (Iowa) *Professor of English*
Sanford Schwartz, Ph.D. (Princeton) *Associate Professor of English*
Robert A. Secor, Ph.D. (Brown) *Associate Professor of English and American Studies*
Daniel Walden, Ph.D. (NYU) *Professor of American Studies*
Bruce Weigl, Ph.D. (Utah) *Associate Professor of English*
Stanley Weintraub, Ph.D. (Penn State) *Research Professor of English*
James L. W. West III, Ph.D. (South Carolina) *Professor of English*
Paul N. West, M.A. (Columbia) *Professor of English and Comparative Literature*

Associate Members of the Graduate Faculty
Bernard Asbell, *Associate Professor of English*
John D. C. Buck, Ph.D. (California) *Assistant Professor of English*
Ronald E. Buckalew, Ph.D. (Illinois) *Associate Professor of English*
Robert E. Burkholder, Ph.D. (South Carolina) *Associate Professor of English*
Landon C. Burns, Ph.D. (Yale) *Professor of English*
Davida H. Charney, Ph.D. (Carnegie-Mellon) *Assistant Professor of English*
Patrick G. Cheney, Ph.D (Toronto) *Assistant Professor of English*
Robert P. Fitzgerald, Ph.D. (Iowa) *Associate Professor of English*
Robert H. Gannon *Associate Professor of English*
Richard E. Gidez, Ph.D. (Ohio) *Associate Professor of English and American Studies*
Stephen R. Grecco, M.F.A. (Yale) *Associate Professor of English*
Charlotte Holmes, M.F.A. (Columbia) *Assistant Professor of English*
Theodore E. Kiffer, Ph.D. (Penn State) *Associate Professor of English Linguistics*

Laura L. Knoppers, Ph.D. (Harvard) *Assistant Professor of English*
James R. McAdams, Ph.D. (NYU) *Assistant Professor of English*
John W. Moore, Jr., Ph.D. (Stanford) *Assistant Professor of English*
Carla J. Mulford, Ph.D. (Delaware) *Assistant Professor of English*
James M. Rambeau, Ph.D. (Rutgers) *Associate Professor of English and American Studies*
Angelita Reyes, Ph.D. (Iowa) *Assistant Professor of Comparative Literature and English*
Peter H. Schneeman, Ph.D. (Minnesota) *Associate Professor of English and Comparative Literature*
Marie J. Secor, Ph.D. (Brown) *Assistant Professor of English*
John L. Selzer, Ph.D. (Miami) *Associate Professor of English*
Kenneth A. Thigpen, Ph.D. (Indiana) *Associate Professor of English and Comparative Literature*
Charles W. Thompson, M.A. (Virginia) *Associate Professor of English*
Emily J. Toth, Ph.D. (Johns Hopkins) *Associate Professor of English and American Studies*

Candidates for the M.A. in English may specialize in English and American literature or in writing. Students whose interests are largely in the study of literature, or who intend to continue for the doctorate, specialize in literature. Students who, on the basis of their overall record and a writing sample, are accepted into the writing program may concentrate in the writing of poetry, fiction, or nonfiction, or in editing and technical writing. The M.F.A. in English prepares candidates for professional careers as writers of fiction, poetry, or nonfiction employing artistic techniques. The M.Ed. is offered in cooperation with the College of Education.

The department offers a strong teacher-training program, and most graduate students in English have the opportunity to serve as teaching assistants. Students usually begin by teaching basic composition courses, but there are opportunities for advanced students to teach courses in business writing, technical writing, fiction writing, poetry writing, and humanities, and to serve as tutors in the Writing Center.

Admission Requirements

Scores from the Graduate Record Examination (GRE) Aptitude Tests (verbal and quantitative) are required for admission. Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin*.

Applicants should have a junior-senior average of 3.20, although exceptions may be made for students with special backgrounds, abilities, and interests.

For admission, M.A. students should have strong backgrounds in English courses: 18 credits beyond freshman composition are a minimum, but the department prefers at least 24 credits. All applicants should submit writing samples indicating their ability to do analytical or original work.

For admission into the M.F.A. program, students must have a baccalaureate degree (with substantial work in English), a portfolio of publishable student writing, and the intention to pursue a career as a professional writer.

To be considered for the doctoral program, students must have completed an M.A. in English or its equivalent. The records of potential students should indicate promise of superior work in doctoral study.

Master's Degree Requirements

Candidates for the M.A. take at least 33 credits, 6 of which may be earned by writing a thesis. There is also a 3-credit thesis option, which consists of three substantial essays bound together in consistent format. Each essay must demonstrate the ability to formulate and state meaningfully the results of scholarly investigation or critical analysis. M.A. students with an emphasis in fiction writing or poetry writing may complete their degrees by submitting a body of original work.

M.A. candidates must fulfill the language requirement in one foreign language. All master's candidates are required to take ENGL 501. Other courses are required for students specializing in one of the writing areas. All M.A. candidates must pass an M.A. examination based on a posted list of authors.

M.F.A. candidates are required to take 48 credits, distributed as follows:

15 credits in ENGL 512, 513, or 515, as appropriate, and ENGL 596
6-12 credits in ENGL 600 or 610 for the final project
6-12 credits in writing and/or literature electives (400- and 500-level courses)
15 credits in literature at the 500 level

Candidates will complete an examination within their area of specialization and a final project that will be a book-length manuscript of publishable quality.

Candidates for the M.Ed. take at least 33 credits, 6 of which must be in a field of professional education. There are no foreign language or thesis requirements. All M.Ed. candidates must pass the M.A. examination and submit a final paper to the department.

Doctoral Degree Requirements

The Ph.D. degree does not require a specific number of credits. With the help of departmental graduate advisers, students select a program of small seminars or reading courses. Required courses are ENGL 501, 581, and 6 credits of course work in the area of philology. To complete their programs, students must show reading proficiency in two foreign languages, pass written comprehensive examinations, and write and defend a doctoral dissertation.

Student Aid

In addition to the fellowships, traineeships, graduate assistantships, and other forms of financial aid described in the STUDENT AID section of the *Graduate Bulletin,* the following awards typically have been available to graduate students in this program:

Edwin Earle Sparks Dissertation Fellowship in the Humanities — Available to a doctoral candidate in one of the following graduate programs: classics, comparative literature, English, French, German, history, linguistics, philosophy, religious studies, Slavic languages and literatures, Spanish, and speech communication; stipend $8,040 plus waiver of tuition. Apply to department before February 1.

Edwin Earle Sparks Fellowships in the Humanities (8) — Available to beginning graduate students in one of the following graduate programs: classics, comparative literature, English, French, German, history, linguistics, philosophy, religious studies, Slavic languages and literatures, Spanish, and speech communications; stipend $6,740 plus waiver of tuition. Apply to department before February 1.

Ben Euwema Memorial Scholarship — Travel funding for graduate degree candidates; consideration will be given to all currently enrolled graduate students in English. Preference will be given to students at the Ph.D. thesis stage, particularly those who need to travel to complete their research; number of awards and amount of each award will be determined each year.

Folger Institute Fellowships — Penn State is a member of the Folger Institute of Renaissance and Eighteenth-Century Studies. Graduate students in English are eligible for Folger Institute Fellowships to study in seminars and workshops at the Folger Library, Washington, D.C.

Katey Lehman Fellowship — Provides $5,500 plus tuition for a year's study in poetry or fiction writing leading toward an M.A. or M.F.A. in English. It permits full-time study and research, and involves no teaching duties. Fellowship holders are eligible for graduate assistantships with a similar stipend and tuition grant during the second year of study.

ENGLISH (ENGL)

407. History of the English Language (3)
408. Applied English Language Analysis (3)
410. Rhetorical Theory and Practice (3)
411. Problems of Style (3)
412. Advanced Fiction Writing (3 per semester, maximum of 6)
413. Advanced Poetry Writing (3 per semester, maximum of 6)
414. Biographical Writing (3)
415. Advanced Nonfiction Writing (3 per semester, maximum of 6)
416. (COMM 416) Science Writing (3 per semester, maximum of 6)
417. The Editorial Process (3)
418. Advanced Technical Writing and Editing (3 per semester, maximum of 6)
419. Advanced Business Writing (3)
421. Advanced Expository Writing (3)
422. Fiction Workshop (3 per semester, maximum of 6)
423. Poetry Writing Workshop (3 per semester, maximum of 6)
425. Nonfiction Workshop (3 per semester, maximum of 6)
428. The American Renaissance (3)
432. The American Novel to 1900 (3)
433. The American Novel: 1900-1945 (3)
435. The American Short Story (3)
436. American Fiction Since 1945 (3)
437. The Poet in America (3)
438. American Drama (3)
439. American Nonfiction Prose (3)

441. Chaucer (3)
443. The English Renaissance (3)
444. Shakespeare (3)
445. Shakespeare's Contemporaries (3)
446. Milton (3)
451. The Restoration and the Eighteenth Century (3)
455. The English Novel to Jane Austen (3)
460. The Romantics (3)
464. The Victorians (3)
465. Victorian Novel (3)
475. Modern British Fiction (3)
477. Modern Poetry (3)
478. British and Irish Drama Since 1890 (3)
484. (L A 484) Computational and Quantitative Stylistics (3)
488. (C LIT 488) Modern Continental Drama (3)
490. Women Writers and Their Worlds (3)
491. Literature for Teachers in Secondary Schools (3)
493. (AM ST 493) The Folktale in American Literature (3)
494. Research Topics (1-12)
495. Internship (3-12)
496. Independent Studies (1-18)
497. Special Topics (1-9)
499. Foreign Study — English (3-6)

501. Materials and Methods of Research (3) Materials and techniques of research in English and American literary history; form and content of theses. Required of all graduate students with an English major.

502. Theory and Teaching of Composition (3) Study of grammar, logic, rhetoric, and style in their applicability to teaching composition.

503. (RCLED 503) Research Methods in Composition (3) Introduction to the issues and methods of empirical research in composition.

506. The English Language (3) A problem-centered approach to literary and oral forms of English, utilizing historical and analytic perspectives.

508. Computer Applications for Writers and Humanities Scholars (3) Computer applications for writers and humanities scholars: introduction to terminal-editing, retrieval, bibliographic, and textual analysis systems.

512. The Writing of Fiction (3 per semester, maximum of 12) Supervised workshop in advanced techniques of writing fiction.

513. The Writing of Poetry (3 per semester, maximum of 12) For the student with considerable experience in writing poetry; a workshop devoted to advanced poetic technique.

515. The Writing of Nonfiction (3 per semester, maximum of 12) Supervised workshop in advanced nonfiction techniques.

518. Business and Technical Writing: Current Theory (3) Intensive examination of current theories and practice in business and technical communication; written projects exploring specific theories and problems.

521. Old English Language (3) An introduction to the main features of the Old English language; readings in simple Old English prose and poetry.

522. Beowulf (3) Reading and critical analysis. Prerequisite: ENGL 521.

540. Studies in Elizabethan Prose and Poetry (1-3 per semester, maximum of 6) Major figures studied will vary from year to year. Writers studied might include figures such as Spenser and Sidney.

541. Medieval Studies (1-3 per semester, maximum of 6) Studies in medieval English literature. Topics studied might include medieval romances, drama, or major figures aside from Chaucer.

542. Middle English Literature (3) Introduction to Middle English and its dialects; study of the literature of the period exclusive of Chaucer.

543. Studies in Early Seventeenth-Century Literature (1-3 per semester, maximum of 6) Major figures studied will vary from year to year. Writers studied might include Donne, Herbert, Jonson, Bacon.

545. Chaucer (1-3 per semester, maximum of 6) Major and minor works of Geoffrey Chaucer. The works studied will vary from year to year.

546. Milton (3) The poetry and prose of John Milton.

548. Elizabethan and Jacobean Drama (1-3 per semester, maximum of 6) English drama from 1558 to 1642, exclusive of Shakespeare.

549. Shakespeare (1-3 per semester, maximum of 6) Special problems of sources, chronology, text, characterization, and motivation in the drama.

550. English Literature 1660-1800 (1-3 per semester, maximum of 6) Major figures studied will vary from year to year. Writers studied might include Dryden, Swift, Pope, Johnson, Fielding, Gibbon.

551. English Drama 1660-1800 (1-3 per semester, maximum of 6) Major figures studied will vary from year to year. Writers studied might include Wycherley, Farquahar, Dryden, Congreve, Etherege.

554. Studies in Early American Literature (1-3 per semester, maximum of 6) Major figures studied will vary from year to year. Writers studied might include Bradstreet, Taylor, Mather, Franklin, Edwards, Paine.

556. Eighteenth-Century British Fiction (1-3 per semester, maximum of 6) Major figures studied might include Defoe, Smollet, Fielding, Richardson, Sterne.

558. Nineteenth-Century British Fiction (1-3 per semester, maximum of 6) Major figures studied will vary from year to year. Writers studied might include Dickens, Thackeray, the Brontës, George Eliot, Hardy.

559. Studies in Twentieth-Century British Fiction (1-3 per semester, maximum of 6) Major figures studied will vary from year to year. Writers studied might include Conrad, Lawrence, Woolf, Huxley, Green, Fowles.

560. American Romanticism (1-3 per semester, maximum of 6) Major figures studied will vary from year to year. Writers studied might include Hawthorne, Melville, Emerson, Thoreau, Whitman.

561. Studies in the Romantic Movement (1-3 per semester, maximum of 6) Major figures studied will vary from year to year. Writers studied might include Blake, Wordsworth, Coleridge, Byron, Shelley, Keats.

562. Studies in the Literature of Victorian England (1-3 per semester, maximum of 6) Figures will vary from year to year. Writers studied might include Tennyson, Browning, Arnold, Newman, Ruskin, Trollope.

564. Studies in Nineteenth-Century American Literature (1-3 per semester, maximum of 6) Writers will vary from year to year. Writers studied might include Cooper, Poe, Dickinson, Twain, James.

573. Studies in Twentieth-Century British Literature (1-3 per semester, maximum of 6) Major figures studied will vary from year to year. Writers studied might include Yeats, Conrad, Joyce, Shaw, Lawrence, Auden.

574. Studies in Twentieth-Century American Literature (1-3 per semester, maximum of 6) Figures studied will vary from year to year. Writers studied might include Dreiser, Wharton, Eliot, Hemingway, Fitzgerald, Faulkner, O'Neill, Williams.

575. Experimentalism and Modernism in Twentieth-Century British and American Fiction (1-3 per semester, maximum of 6) Figures studied will be drawn from the era of Joyce and Virginia Woolf to the present.

576. Studies in Twentieth-Century American Fiction (1-3 per semester, maximum of 6) Concentrated study in such major American writers as Hemingway, Faulkner, and Fitzgerald.

578. Studies in Modern British Drama (1-3 per semester, maximum of 6) Figures studied will be drawn from the era of Shaw and Wilde to the present.

581. Studies in Modern British and American Criticism (1-3 per semester, maximum of 6)

582. Contemporary Discourse: Rhetoric, Poetics, and Composition (3) Exploration of the dimensions of discourse as reflected in recent theories of rhetoric, poetics, and literary criticism.

585. Studies in British Fiction (1-3 per semester, maximum of 6)

586. Readings in Literature (1-12) Programs of readings designed to meet specific needs of individual students.

588. Studies in American Fiction (1-3 per semester, maximum of 6)

589. Studies in American Poetry (1-3 per semester, maximum of 6)

595. Internship (1-3 per semester, maximum of 12) Supervised practicum in fields appropriate to the English major. Prerequisite: departmental approval.

596. Individual Studies (1-9)

597. Special Topics (1-9)

602. Supervised Experience in College Teaching (1-3 per semester, maximum of 6)

ENTOMOLOGY (ENT)

CHARLES W. PITTS, *Head of the Department*
106 Patterson Building
814-865-1895

Degrees Conferred: Ph.D., M.S., M.Agr.

Senior Members of the Graduate Faculty
Robert A. Byers, Ph.D. (Purdue) *Adjunct Professor of Entomology*
E. Alan Cameron, Ph.D. (California) *Professor of Entomology*
Clarence H. Collison, Ph.D. (Michigan State) *Associate Professor of Entomology*
Arthur A. Hower, Ph.D. (Penn State) *Professor of Entomology*
Larry A. Hull, Ph.D. (Penn State) *Associate Professor of Entomology*
Ke Chung Kim, Ph.D. (Minnesota) *Professor of Entomology*
Ralph O. Mumma, Ph.D. (Penn State) *Professor of Chemical Pesticides*
Charles W. Pitts, Ph.D. (Kansas State) *Professor of Entomology*
Zane Smilowitz, Ph.D. (Cornell) *Professor of Entomology*
Thomas Smyth, Jr., Ph.D. (Johns Hopkins) *Professor of Entomology*
Robert J. Snetsinger, Ph.D. (Illinois) *Professor of Entomology*
William G. Yendol, Ph.D. (Purdue) *Professor of Entomology*

Associate Members of the Graduate Faculty
William M. Bode, Ph.D. (Ohio State) *Assistant Professor of Entomology*
Dennis D. Calvin, Ph.D. (Kansas State) *Assistant Professor of Entomology*
Edwin G. Rajotte, Ph.D. (Rutgers) *Assistant Professor of Entomology*
Michael C. Saunders, Ph.D. (Georgia) *Assistant Professor of Entomology*
Alfred G. Wheeler, Jr., Ph.D. (Cornell) *Adjunct Associate Professor of Entomology*

Entomology, the science that deals with insects and related arthropods, specifically attempts to maximize the benefits and minimize the impacts of insects on humans by studying their relationships to plants and animals. The program emphasizes population management of insects and prepares students for a professional career in research, teaching, extension, or industry through advanced studies of structure-function, development, taxonomy, and ecology of insects; principles of integrated pest management; and biological and chemical control techniques. A student also may specialize in the biology and population management of insect pests of agronomic or horticultural crops, forests, commercial mushrooms, and in the toxicology and technology of biological and chemical control. Advanced studies in systematics, ecology, physiology, insect resistance in plants, insect pathology, pesticide chemistry, or pollination biology also may be taken. Modern laboratories, greenhouses, well-equipped research facilities, and field research plots are available for graduate study.

Admission Requirements
Scores from the Graduate Record Examination (GRE) are required for admission. At the discretion of a graduate program, a student may be admitted provisionally for graduate study in a program without these scores. Requirements listed below are in addition to general Graduate School requirements

stated in the GENERAL INFORMATION section of the *Graduate Bulletin*.

For admission a student must present 24 credits in biological sciences, including entomology. Chemistry through organic, physics, mathematics through calculus, statistics, and computer application are required. Admission is normally to the M.S. program.

Master's Degree Requirements

The Master of Agriculture degree in Entomology is a terminal professional degree and is particularly suited for training chemical technical personnel, pest management specialists, and for various government staff positions. A minimum of 30 graduate credits (400 and 500 level) are required, with at least 20 credits earned in residence and 12 credits in Entomology. A maximum of 10 credits may be earned in Special Problems or Special Internship Training. A "term paper" or "internship report" for which up to 3 credits may be given is required. The student must earn at least one seminar credit and must pass a departmental oral examination. These requirements must be met within three calendar years after entering the program.

The Master of Science degree in Entomology is an intermediate degree leading toward the development of special knowledge in entomology. It provides training for prospective doctoral candidates. A minimum of 30 graduate credits, of which 20 must be earned on the University Park Campus, 18 must be graduate courses or research (500 or 600 level), and 12 must be organized graduate-credit courses (400 and 500 level), are required. An acceptable thesis, equivalent to at least 6 credits (600 level), must be submitted. All students must take or have the equivalent of the two core courses (ENT 540, 541) and pass a departmental oral examination. A minor is not mandatory.

Doctoral Degree Requirements

The degree of Doctor of Philosophy signifies high scholastic achievement and demonstrated capability in independent research. Although there is no formal credit requirement, it will normally require at least three years of graduate work. Some of the work may be completed off campus or on a part-time basis, but between the time of acceptance as a candidate and completing the degree requirements the student must spend three academic sessions in residence within a twelve-month period. The department requires that all students have the two core courses or the equivalent (ENT 540, 541) and a minimum of 10 additional credits in organized graduate courses in the department or cognate fields approved by the student's committee, 2 credits in departmental seminars, and 3 credits in statistics. A minor is not required, but a student may elect a minor in general studies or a related field. This consists of no fewer than 15 credits.

The enrichment requirement for the Ph.D. degree may be satisfied by taking at least 9 course credits in a discipline other than entomology. There is no foreign language requirement for the Ph.D. degree. However, depending on the nature of the thesis research and with the advice and consent of the Doctoral Committee, competency in a foreign language may be required as a part of the doctoral studies of certain students.

Student Aid

Graduate assistantships available to students in this program and other forms of student aid are described in the STUDENT AID section of the *Graduate Bulletin*.

ENTOMOLOGY (ENT)

402. (V SC 402) Biology of Animal Parasites (3) *Kim*
425. Freshwater Entomology (3) *Kim*
444. (PPATH 444) Biotechnology in Agriculture (2)
452. Urban Entomology (2) *Snetsinger*
455. Economic Entomology (3) *Bode*
456. Methods and Strategies for Insect Pest Management (3) *Hower*
496. Independent Studies (1-18)
497. Special Topics (1-9)

530. Host Plant Resistance to Insects (2) Evaluation and identification of plant resistance to insect and mite attack. Prerequisites: 10 credits in entomology and/or plant science.

531. Insect Toxicology (2) General principles of toxicology and survey of the actions of substances toxic to insects.

539. Chemical Ecology of Insects (3) Interactions of insects with environmental chemicals, including natural and synthetic compounds; host finding and other behavior modifying cues.

540. Insect Structure and Function (5) Morphology, physiology of insects; literature and history of entomology; for advanced students with minimal entomological training.

541. Taxonomy, Ecology, and Evolution of Insects (5) Taxonomic analysis and classification of insects; ecology and behavior; insect/host interactions; evolution and phylogeny of insects.

542. (BIOL 542, WILDL 542) Systematics (3) Principles and methods of classification, phylogeny, and speciation; taxonomic techniques; analysis of species; causal interpretation of animal diversity.

543. Biological Control and Pathology of Insects (3) Arthropod population control by entomogenous insects and microorganisms. Prerequisite: consent of program.

590. Colloquium (1-3)

593. (ANTH 593, BIOL 593, GEOSC 593, INTAG 593) Tropical Field Studies (Organization for Tropical Studies) (8) An intensive field course concentrating on field problems, experimental design, and data analysis in tropical habitats. Prerequisite: approval by the Committee on Tropical Studies.

595. Internship (10-12) Supervised field experience and study related to the student's major professional interest. Written and oral critique of activity required. Limited to students for Master of Agriculture degree in entomology. Prerequisites: approval of proposed assignment by adviser prior to registration; cumulative G.P.A. of 3.00 or higher; completion of entomology core courses.

596. Individual Studies (1-9)

597. Special Topics (1-9)

602. Supervised Experience in College Teaching (1-3 per semester, maximum of 6)

ENVIRONMENTAL ENGINEERING (ENV E)

MICHAEL S. BRONZINI, *Head of the Department of Civil Engineering*
212 Sackett Building
814-865-8391

Degrees Conferred: Ph.D., M.S., M.Eng.

Senior Members of the Graduate Faculty
Gert Aron, Ph.D. (California), P.E. *Professor of Civil Engineering*
Mriganka M. Ghosh, Ph.D. (Illinois) *Professor of Civil Engineering*
Robert J. Heinsohn, Ph.D. (Michigan State), P. E. *Professor of Mechanical Engineering*
David F. Kibler, Ph.D. (Colorado State), P.E. *Professor of Civil Engineering*
David A. Long, Ph.D. (Penn State), P.E. *Professor of Civil Engineering*
Archibald J. McDonnell, Ph.D. (Penn State) *Professor of Civil Engineering*
Arthur C. Miller, Ph.D. (Colorado State), P.E. *Professor of Civil Engineering*
Joseph R. Reed, Ph.D. (Cornell), P.E. *Professor of Civil Engineering*
Raymond W. Regan, Ph.D. (Kansas), P.E. *Associate Professor of Civil Engineering*
Richard F. Unz, Ph.D. (Rutgers) *Professor of Environmental Microbiology*

This program prepares students for careers in (1) facility and system design; (2) systems management; (3) environmental monitoring; (4) process development; or (5) education and research in any of the environmental areas of water quality management (potable, industrial, and wastewater), water resources management, and air pollution control.

Admission Requirements
Scores from the Graduate Record Examination (GRE) Aptitude Test (verbal, quantitative, and analytical) are required by the Department of Civil Engineering for completion of the admission process. Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin*.

The entering student normally should be a graduate from an accredited program in engineering. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. Applicants must submit Graduate Record Examination Aptitude test scores. Entering graduate students for whom English is not the first language are required to have a score of

at least 560 on the TOEFL (Test of English as a Foreign Language) examination. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

Degree Requirements

Continuous registration is required for all graduate students until the thesis or engineering report is approved.

In addition to demonstrating competence in English, each candidate for the Ph.D. degree must meet a foreign language or communication skills requirement established by the department. A thesis is required for the M.S. degree. An engineering report is required for the M.Eng. degree.

Other Relevant Information

The following courses offered by the Department of Civil Engineering are appropriate for students majoring in Environmental Engineering (course descriptions are given under Civil Engineering): C E 451, 462, 465, 472, 474, 475, 476, 477, 479, 496, 497, 551, 553, 554, 564, 570, 571, 572, 574, 575, 577, 579, 580, 596, and 597. Appropriate courses offered by other departments include BIOCH 401, 402, 425; CHEM 405; GEOSC 452; I E 403, 405, 509, 510; M E 405, 470, 521, 571; METEO 454; MICRB 400; NUC E 420; PPATH 424; PL SC 419; PUB A 578; R PL 400, 410, 510, 520.

Student Aid

In addition to the fellowships, traineeships, graduate assistantships, and other forms of financial aid described in the STUDENT AID section of the *Graduate Bulletin,* the following awards typically have been available to graduate students in this program:

W. S. Elliott Fellowship — Available to a graduate student who is a graduate of Penn State and is interested in engineering research; stipend variable. Apply to Office of the Dean, College of Engineering, 101 Hammond Building.

Cecil M. Pepperman Memorial Graduate Fellowship — Available to a graduating senior who plans to enroll at Penn State as a graduate student in Civil Engineering specializing in water pollution control, environmental sanitation, waste treatment and management, or related fields. More information can be obtained from the Department of Civil Engineering, 212 Sackett Building.

ENVIRONMENTAL POLLUTION CONTROL (E P C)

RICHARD F. UNZ, *In Charge of Graduate Programs in Environmental Pollution Control*
226B Merrell R. Fenske Laboratory
814-865-1415

Degrees Conferred: M.S., M.E.P.C., M.Eng.

Senior Members of the Graduate Faculty (University Park)

Frank F. Aplan, Sc.D. (MIT) *Professor of Metallurgy and Mineral Processing*
Gert Aron, Ph.D. (California), P.E. *Professor of Civil Engineering*
Dale E. Baker, Ph.D. (Missouri) *Professor of Soil Chemistry*
Paul Barton, Ph.D. (Penn State), P.E. *Assistant Professor of Chemical Engineering*
Jean-Marc Bollag, Ph.D. (Basel) *Professor of Soil Microbiology*
Elsworth R. Buskirk, Ph.D. (Minnesota) *Professor of Applied Physiology*
Robert L. Cunningham, Ph.D. (Washington State) *Professor of Soil Genesis and Morphology*
Brian A. Dempsey, Ph.D. (North Carolina) *Assistant Professor of Civil Engineering*
David R. DeWalle, Ph.D. (Colorado State) *Professor of Forest Hydrology*
Alfred J. Engel, Ph.D. (Wisconsin) *Professor of Chemical Engineering*
Frederick G. Ferguson, Ph.D. (Pennsylvania) *Professor of Veterinary Science*
Mriganka M. Ghosh, Ph.D. (Illinois) *Professor of Civil Engineering*
Richard L. Gordon, Ph.D. (MIT) *Professor of Mineral Economics*
Robert J. Heinsohn, Ph.D. (Michigan State), P.E. *Professor of Mechanical Engineering*
Friedrich G. Helfferich, Dr.rer.nat. (Göttingen, Germany) *Professor of Chemical Engineering*
Richard Hogg, Ph.D. (California-Berkeley) *Professor of Mineral Processing*
Albert R. Jarrett, Ph.D. (Penn State) *Professor of Agricultural Engineering*
Robert G. Jenkins, Ph.D. (Leeds) *Professor of Fuel Science*
Robert L. Kabel, Ph.D. (Washington), P.E. *Professor of Chemical Engineering*
David F. Kibler, Ph.D. (Colorado State) *Professor of Civil Engineering*

C. Gregory Knight, Ph.D. (Minnesota) *Professor of Geography*
Manfred Kroger, Ph.D. (Penn State) *Professor of Food Science*
David A. Long, Ph.D. (Penn State), P.E. *Professor of Civil Engineering*
James A. Lynch, Ph.D. (Penn State) *Associate Professor of Forest Hydrology*
Archibald J. McDonnell, Ph.D. (Penn State) *Professor of Civil Engineering*
Arthur C. Miller, Ph.D. (Colorado State) *Professor of Civil Engineering*
Richard R. Parizek, Ph.D. (Illinois) *Professor of Geology*
Gary W. Petersen, Ph.D. (Wisconsin) *Professor of Soil Genesis and Morphology*
C. Channa Reddy, Ph.D. (Indian Institute of Science) *Associate Professor of Veterinary Science*
Raymond W. Regan, Ph.D. (Kansas), P.E. *Associate Professor of Civil Engineering*
Andrew S. Rogowski, Ph.D. (Iowa State) *Adjunct Professor of Soil Physics*
George H. K. Schenck, Ph.D. (Penn State) *Associate Professor of Mineral Economics*
William E. Sharpe, Ph.D. (West Virginia) *Associate Professor of Forest Hydrology*
George Simkovich, Ph.D. (Penn State) *Professor of Materials Science*
William E. Sopper, Ph.D. (Yale) *Professor of Forest Hydrology*
Dennis W. Thomson, Ph.D. (Wisconsin) *Professor of Meteorology*
Richard F. Unz, Ph.D. (Rutgers) *Professor of Environmental Microbiology*
William B. White, Ph.D. (Penn State) *Professor of Geochemistry*

Associate Members of the Graduate Faculty (University Park)
Herschel A. Elliott, Ph.D. (Delaware) *Associate Professor of Agricultural Engineering*
Dennis Lamb, Ph.D. (Washington) *Associate Professor of Meteorology*
Stanley P. Mayers, Jr., M.D. (Pennsylvania) *Professor of Health Planning and Administration*
William H. Patton, Ph.D. (Wisconsin) *Assistant Professor of Veterinary Science*
Barry E. Scheetz, Ph.D. (Penn State) *Senior Research Associate and Associate Professor of Solid State Science*

Senior Members of the Graduate Faculty (Penn State Harrisburg)
Barnard H. Bissinger, Ph.D. (Cornell) *Professor of Mathematics*
Robert J. Brown, Ph.D. (NYU) *Associate Professor of Finance*
Rupert F. Chisholm, Ph.D. (Case Western Reserve) *Associate Professor of Management*
Charles A. Cole, Ph.D. (Rutgers) *Professor of Engineering*
Francis Ferguson, Ph.D. (Columbia) *Professor of Environmental Design*
Irving Hand, M.C.P. (MIT) *Professor of State and Regional Planning*
Christopher K. McKenna, Ph.D. (NYU) *Associate Professor of Management Science*
Robert F. Munzenrider, Ph.D. (Georgia) *Associate Professor of Public Administration*
Vedula N. Murty, Ph.D. (Purdue) *Professor of Mathematics and Statistics*
James E. Skok, Ph.D. (Maryland) *Associate Professor of Public Administration*

Associate Members of the Graduate Faculty (Penn State Harrisburg)
Robert A. Simko, Ph.D. (Indiana) *Associate Professor of Geography and Social Science*
Clifford H. Wagner, Ph.D. (SUNY) *Associate Professor of Mathematics*
Scott E. Walters, Ph.D. (Tennessee) *Assistant Professor of Chemistry*

This intercollege master's degree program, available at both University Park (M.S., M.E.P.C., and M.Eng.) and Penn State Harrisburg (M.E.P.C., M.Eng.), deals with the various aspects of the control of air and water pollution and the disposal of solid wastes. Options in air, water, solid waste, and occupational health are available. Graduate instruction is under the direction of an interdisciplinary faculty committee and the departments participating in the program. The graduate faculty consists of members who have teaching and research interests in the area of environmental pollution control. Currently, forty-three faculty from nineteen departments representing five colleges are participating in the program at University Park; fifteen faculty and five graduate programs participate at Penn State Harrisburg. A student is affiliated with one of these departments on the basis of his or her specific area of interest and is advised by an E.P.C. faculty member in that department. Maximum flexibility is maintained by the program in an effort to meet both the needs of the individual student and the pollution control activity in which he or she wants to participate. Nearly all of the graduate faculty members are involved in research relating to their field of expertise and, where projects are being funded, support opportunities may be available.

Admission Requirements
Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin*.

The E P C program is designed for students with backgrounds in science and engineering. Admission will be granted upon recommendation of the head of the academic department with which the student wishes to affiliate and the E P C program chairman. Normal admission requirements include

mathematics through integral calculus plus two courses each in both general chemistry and physics. Scores from the Graduate Record Examination (GRE) are not an entrance requirement unless an applicant intends to apply for a graduate assistantship or fellowship or unless he or she has a junior-senior grade-point average below 3.00. There is no foreign language requirement.

Students with a 3.00 junior-senior average and with appropriate backgrounds in mathematics and science will be considered for admission. The best-qualified applicants will be accepted. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests. Entering graduate students for whom English is not the first language are required to have a score of at least 560 on the TOEFL (Test of English as a Foreign Language) examination.

Degree Requirements

Candidates are required to pass 10 credits of core courses, which include C E 472, 474, or 580; F SC 430; C E 476; and 1 credit of E P C 590. All but 6 of the total 30 credits required must be selected from a recommended course list. If the option to prepare a thesis is selected, students must schedule at least 12 credits at the 500 level, write a thesis on an area concerned with environmental pollution, and take at least 6 credits of 600-level thesis research in their department of affiliation. Only 6 credits of 600-level course work may count toward the 30-credit minimum degree requirement. Students who select the nonthesis option must schedule at least 9 credits at the 500 level, which may not include seminar credits or any paper writing credits, and must submit a master's paper.

Student Aid

Graduate assistantships available to students in this program and other forms of student aid are described in the STUDENT AID section of the *Graduate Bulletin*.

ENVIRONMENTAL POLLUTION CONTROL (E P C)

590. Colloquium (1-3)

EXERCISE AND SPORT SCIENCE (EXSCI)

R. SCOTT KRETCHMAR, *Head of the Department*
113 White Building
814-863-4493

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Senior Members of the Graduate Faculty

Elsworth R. Buskirk, Ph.D. (Minnesota) *Professor of Applied Physiology*
Peter R. Cavanagh, Ph.D. (Royal Free Medical) *Professor of Locomotion Studies*
Robert W. Christina, Ph.D. (Maryland) *Professor of Exercise and Sport Science*
Peter A. Farrell, Ph.D. (Arizona) *Associate Professor of Applied Physiology*
Dorothy V. Harris, Ph.D. (Iowa) *Professor of Exercise and Sport Science*
James L. Hodgson, Ph.D. (Minnesota) *Associate Professor of Applied Physiology*
R. Scott Kretchmar, Ph.D. (Southern California) *Professor of Exercise and Sport Science*
John A. Lucas, Ed.D. (Maryland) *Professor of Exercise and Sport Science*
Herberta M. Lundegren, Ph.D. (Iowa) *Professor of Physical Education*
Richard C. Nelson, Ph.D. (Michigan State) *Professor of Exercise and Sport Science*
John B. Shea, Ph.D. (Michigan) *Associate Professor of Exercise and Sport Science*
Ronald A. Smith, Ph.D. (Wisconsin) *Professor of Exercise and Sport Science*
Karl G. Stoedefalke, Ph.D. (Illinois) *Professor of Exercise and Sport Science*
James G. Thompson, Ph.D. (Penn State) *Professor of Exercise and Sport Science*

Associate Members of the Graduate Faculty

Virginia Fortney, Ph.D. (Purdue) *Assistant Professor of Exercise and Sport Science*
James D. Gallagher, Ph.D. (Penn State) *Associate Professor of Physical Education*
Thomas J. Griffiths, Ed.D. (Maryland) *Affiliate Associate Professor of Exercise and Sport Science*
Larry Kenney, Ph.D. (Penn State) *Research Asssociate in Applied Physiology*
Joseph L. Loomis, M.S. (Penn State) *Research Associate in Applied Physiology*
W. Channing Nicholas, M.D. (Pennsylvania) *Associate Professor of Applied Physiology*
Ralph J. Sabock, Ph.D. (Ohio State) *Associate Professor of Physical Education*
Robert J. Scannell, Ph.D. (Penn State) *Professor of Physical Education*

The graduate programs in Exercise and Sport Science are research oriented and are designed to meet the specific goals and interests of the student. The primary goal of the program is to provide students the opportunity to study in depth in one of the areas of specialization and to develop necessary research skills to enhance their professional competence. The master's program is designed to prepare students for future graduate study, while the doctoral program is directed toward careers in research and in teaching at the advanced undergraduate and graduate levels in colleges and universities. The areas of specialization available at the master's level only include exercise specialist, performance assessment, and sports administration. The programs available at both the master's and doctoral levels are adapted physical education, biomechanics, history of sport and physical education, motor learning and control, physiology of exercise, and sport psychology. Several well-equipped research facilities are available to support graduate study including the Biomechanics Laboratory, Motor Behavior Laboratory, Noll Laboratory for Human Performance Research, Sports Research Institute, and the Sport Psychology Laboratory.

Admission Requirements

Scores from the Graduate Record Examination (GRE) are required for admission. At the discretion of a graduate program, a student may be admitted provisionally for graduate study in the program without these scores. Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin*.

The minimum requirements for admission to the master's program include 3.00 junior-senior grade-point average, satisfactory recommendations, a total of 1,000 or higher on the verbal and quantitative sections of the GRE, and appropriate background courses in physical, biological, behavioral, and/or social science depending on the intended area of specialization. Applicants for all specializations except sports administration must have had courses in exercise physiology, kinesiology/biomechanics, history/philosophy/sociology of sport, motor learning, and sport psychology. Deficiencies in these areas must be completed before the degree is conferred and credits generally will not be applied to those required for graduation. Candidates from majors other than physical education are welcome to apply, but additional courses will be required. In addition, doctoral applicants need a 3.50 average in a master's degree program, plus documented research capabilities. Experience is highly desirable. A master's degree is required prior to acceptance to the doctoral program. The best-qualified applicants will be accepted up to the number of spaces available for new students. Applicants who do not meet established criteria may be considered on an individual basis.

Master's Degree Requirements

All master's candidates are required to complete a research methods course and an acceptable statistics course; show proficiency in the English language; and write a thesis. In addition, each specialization may require specific courses. The sports administration specialization requires a minimum of 34 credits. All other specializations require a minimum of 30 credits.

Candidates for the Master of Education degree must take 6 credits in a field of professional education.

Doctoral Degree Requirements

Core requirements for all doctoral candidates include a minimum of 6 credits of statistics in sequence, research methods course, master's thesis, familiarity with use of computers, a graduate student seminar, and a foreign language at the intermediate level of comprehension. The foreign language requirement may be waived for D.Ed. candidates on the recommendation of the student's committee. The candidacy and comprehensive examinations include both written and oral sections.

Each student is assigned an adviser in the identified area of specialization. Quotas are established for each specialization resulting in a low student-adviser ratio. At the doctoral level students work closely with their adviser on research projects and, in most cases, on the development of grant proposals and in supervised teaching experiences.

Student Aid

Graduate assistantships available to students in this program and other forms of student aid are described in the STUDENT AID section of the *Graduate Bulletin*.

EXERCISE AND SPORT SCIENCE (EXSCI)

400. Adapted Physical Education (3)
402. Physical Activities for Children in Special Education (3)
405. Development of Exercise Programs (3)

412. Contemporary Problems of Teaching Physical Education in the Inner City Schools (3)
420. Psychosocial Dimensions of Physical Activity (3)
424. The Female in Exercise and Sport (3)
440. (PHIL 440) Philosophy and Sport (3)
441. History of Sport in American Society (3)
442. Sport in Antiquity (3)
443. The Modern Olympic Games (3)
444. History of Athletics in Higher Education (3)
452. Methods, Materials, and Principles of Physical Education in the Elementary School (3)
455. Statistical Methods in Health, Physical Education, and Recreation (3)
456. Physical Fitness Appraisal (3)
457. Exercise Prescription (2)
458. Exercise Science Cast Studies (1)
463. Acquisition of Motor Skills (3)
470. History and Theory of Dance in Education (2)
473. Advanced Modern Dance I (1)
474. Advanced Modern Dance II (1)
480. Exercise Physiology (3)
481. Scientific Basis of Exercise for Older Adults (2)
483. Motor Patterns of Children (3)
484. Sport Biomechanics (3)
489. Intramural Athletics (3)
490. Measurement and Evaluation in Health and Physical Education (2)
491. Organization and Administration of Health and Physical Education in Schools (2)
492. Fitness Programming for Businesses and Agencies (3)
493. Methods and Principles of Athletic Coaching (2)
495A. Practicum in Student Teaching (10)
495B. Field and/or Research Practicum in Exercise Science (6-12)
495C. Exercise Programming for the Older Adult (1)
495D. Field Practicum in Human Performance and Aging (12)
496. Independent Studies (1-18)
497. Special Topics (1-9)

500. (RC PK 500) Individual Study and Research Projects (1-10) Prerequisite: EXSCI 530.

501. Sports Administration (1) An introduction to the field of sports administration through analysis of current issues, developments, literature, and completed research.

520. Psychology of Sport (3) Study of human psychological behavior in sport and physical activity; development of somatopsychic theory of physical activity. Prerequisites: 6 credits in psychology.

522. Sport in Society (3) Examination of the cultural phenomenon of sport; social behavior in sport; institution of sport and relationship with other social institutions. Prerequisite: 3 credits in sociology.

525. Social Psychology of Sport (3) Theory and research concerning the social-psychological basis for understanding social interaction and performance in team and individual sport settings. Prerequisite: 3 credits in social psychology at the 400 or 500 level.

530. (HL ED 530, RC PK 530) Research Techniques in Health and Physical Education and Recreation (3) Research techniques, including methods, research design, techniques for data collection, as applied to relevant problems in the health education field.

532. Tests and Measurements in Physical Education (3) Critical study of tests and measurements available in physical education; methods of constructing and evaluating new tests and measurements. Prerequisite: EXSCI 490.

534. Studies in Curriculum Construction in Physical Education (3) Principles and methods of curriculum building in physical education, emphasizing different psychological and educational points of view.

535. Cross-Cultural Analysis of Sport and Physical Education (3) An analysis of sport and physical education in other cultures and a comparison with the U.S.A.

540. Philosophy of Sport and Physical Education (3) Principles underlying sport and physical education and the meaning of these phenomena in individual lives. Prerequisite: EXSCI 491 or RC PK 465 or 3 credits of philosophy.

555. Internship in Sport Administration (3-10) A supervised internship in the administration of interscholastic, intercollegiate, professional sport, or commercial sport-related enterprises. Prerequisites: 14 credits in sport administration, curriculum supervision area of specialization.

560. Administrative Principles and Management of Athletic Programs (3) Theories and principles of administration and management with focus on the effectiveness and application of those concepts to athletics. Prerequisites: EXSCI 491; 3 credits in administration.

561. Issues in Sports Administration (1) Application of administrative principles and theory to the analysis of issues in sport administration utilizing case studies. Prerequisite: EXSCI 560.

563. Motor Learning (3) Analysis of research evidence related to motor skills; characteristics of beginning and advanced performers; relevant learning principles.

565. Neuromuscular Performance (3) Integrative action of the neural and muscular systems in effecting human movement, with emphasis on motor performance. Prerequisite: EXSCI 480.

567. (PHSIO 567) Advanced Exercise Physiology (3) Physiological changes during exercise, with emphasis on the effects of physical conditioning and training. Prerequisites: BIOL 472, EXSCI 480.

575. Motor Performance of the Handicapped (3) Motor performance of physically handicapped and mentally retarded. Activities and therapeutic exercises for the formulation of individualized programs. Prerequisites: CN ED 409, SPLED 410.

576. Internship in Adapted Physical Education (3) Supervised internship in recreational, educational, or clinical situations; assessment of motor performances, evaluation of activities, and staff conference participation.

577. (PHSIO 577) Applied Cardiovascular Physiology (3) In-depth study of applied electrocardiography and cardiac physiology. Prerequisite: 4 credits in physiology at the 400 or 500 level.

580. (PHSIO 580) Analysis of Body Composition (2) Study of the methods employed in the analysis of body composition. Prerequisite: BIOL 472 or 3 credits in physiology at the 400 or 500 level.

581. Biomechanics (3) Kinetic and kinematic analyses of human motion utilizing electromyography and stroboscopic-photographic techniques. Prerequisites: EXSCI 480, 484.

582. Sport Biomechanics (3) Analysis of sports movements utilizing cinematography, electronic devices, and related research instruments.

583. Survey of Locomotion Studies (3) Mechanical/physiological factors constraining movement; solutions to overcome these constraints; muscle mechanics, locomotion studies, neural control, and gait analysis covered. Prerequisite: E MCH 011 or 012 or EXSCI 048 or I E 553.

584. Electromyographic Kinesiology (3) The theoretical background and practical application of electromyography in understanding human movement and the function of muscles. Prerequisites: EXSCI 480, 484.

585. (PHSIO 585) Applied Physiology: Thermal (3) Physiological mechanisms activated by exposure to environmental temperature. Prerequisite: EXSCI 480 or 3 credits in physiology at the 400 or 500 level.

586. (PHSIO 586) Research Methods in Applied Physiology (3) Historical and current procedures for evaluation of cardio-pulmonary function, metabolism, and thermal balance in humans; lecture, demonstration, and student laboratory. Prerequisite: 3 credits in physiology at the 400 or 500 level.

587. (PHSIO 587) Applied Physiology: Ambient Pressure (3) Physiological mechanisms activated by exposure to environmental pressure. Prerequisite: EXSCI 480 or 3 credits in physiology at the 400 or 500 level.

590. Colloquium (1-3)

595. (PHSIO 595) Internship in Exercise Physiology and Cardiac Rehabilitation (1-15) Clinical and related research aspects of exercise physiology and exercise prescription with respect to cardiac and cardiovascular rehabilitation. Prerequisites: EXSCI 456, 457, 480, PHSIO 571, 572, 590; completion of one year of graduate work.

596. Individual Studies (1-9)

597. Special Topics (1-9)

602. Supervised Experience in College Teaching (1-3 per semester, maximum of 6)

EXTENSION EDUCATION (EXTED)

ANNE L. HEINSOHN, *Chair of the Committee on Extension Education*
110 Armsby Building
814-863-0387

Degrees Conferred: M.Agr., M.Ed.

Senior Members of the Graduate Faculty
Anne L. Heinsohn, Ph.D. (Penn State) *Associate Professor of Extension Education*
Gerald D. Kuhn, Ph.D. (Purdue) *Professor of Food Science*
Jerry H. Reyburn, Ph.D. (Purdue) *Professor of Agricultural and Extension Education*
Robert J. Snetsinger, Ph.D. (Illinois) *Professor of Entomology*
Paul J. Wuest, Ph.D. (Penn State) *Professor of Plant Pathology*

Associate Members of the Graduate Faculty
Joy M. Cantrell, Ed.D. (Mississippi State) *Assistant Professor of Extension Education*
Richard H. Cole, Ph.D. (Penn State) *Associate Professor of Horticulture Extension and Agronomy*
O. Elwood Hatley, Ph.D. (Purdue) *Associate Professor of Agronomy Extension*
Daryl K. Heasley, Ph.D. (Penn State) *Associate Professor of Rural Sociology Extension*
Robert B. Lewis, D.Ed. (North Carolina State) *Professor of Agricultural and Extension Education*
Dennis J. Murphy, Ph.D. (Penn State) *Assistant Professor of Agricultural Engineering Extension*
Paul R. Shellenberger, Ph.D. (Iowa State) *Professor of Dairy Science*

This program is designed to meet the graduate study needs of professionals in various extension, vocational, and adult education positions. Students are required to select a committee to assist in defining professional goals, planning a program of study, selecting appropriate courses, and developing a professional paper within the requirements of the degree program.

Specific objectives of the Extension Education program are (1) to provide a comprehensive program of study that focuses on developing, evaluating, and administering nonformal education programs; (2) to promote an awareness and understanding of significant research in the area of Extension Education; (3) to increase the professional effectiveness of extension personnel; (4) to provide experience for extension personnel or other educators in applying research methodology and problem-solving techniques.

Admission Requirements
Scores from the Graduate Record Examination (GRE) are required for admission. At the discretion of a graduate program, a student may be admitted provisionally for graduate study in a program without these scores. Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin*.

Admission requirements include a baccalaureate degree from an accredited institution, and it is preferred that students have a strong background in agriculture or home economics and a minimum of 12 credits in the social sciences. Students with at least a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. TOEFL scores are required for all students with English as a second language. The best-qualified applicants will be accepted up to the number of spaces that are available for new students.

Degree Requirements
For either degree, a minimum of 30 credits is required, including a 3-credit professional paper. These credits should be distributed as follows: 12 credits in extension techniques, communication, and education; 3-4 credits in statistics; 6-12 credits in a minor area of interest; and 3 credits for the professional paper. For the M.Ed. degree, a minimum of 6 credits in education courses are required. Stu-

dents must take 12 of the 27 credits in course work at the 500 level. A maximum of 10 credits may be earned as a nonresident student.

Student Aid
Graduate assistantships available to students in this program and other forms of student aid are described in the STUDENT AID section of the *Graduate Bulletin.*

EXTENSION EDUCATION (EXTED)

440. (AG ED 440) Communication Methods and Media (3)
450. (AG ED 450) Methodology of Extension Education (3)
455. 4-H/Extension Youth Programs and Volunteer Management (3)
495. Internship (6-18)
496. Independent Studies (1-18)
497. Special Topics (1-9)

515. (R SOC 515) The Cooperative Extension Organization (3) The Cooperative Extension Service as a social system, with emphasis on techniques of organization and program development. Prerequisites: 9 credits in education, communication, and/or social sciences. *Thomson*

590. Colloquium (1-3)

596. Individual Studies (1-9)

597. Special Topics (1-9)

FILM AND VIDEO (FILM)

Degrees Conferred: M.A., M.F.A.

Admission Requirements
Scores from the Graduate Record Examination (GRE) are required for admission. At the discretion of a graduate program, a student may be admitted provisionally for graduate study in a program without these scores. Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin.*

Students with a 3.00 junior-senior average are eligible for admission. Two letters of recommendation are required. Applicants must also submit an autobiographical statement of about 1,000 words indicating the nature of the applicant's interest in Film and Video, reasons for wanting to do graduate work, and aspirations for the future. Applicants to the M.A. program must also submit a critical/historical paper written for an undergradatuate class as a writing sample. Applicants for the M.F.A. program must choose an area of study — either production, direction, or screenwriting — and submit a sample of work appropriate for that area. Exceptions to the above may be made for students with special backgrounds, abilities, and interests.

Degree Requirements
For the M.A. degree, candidates must complete a minimum of 36 credits, at least 18 of which must be at the 500 or 600 level. In some cases, students may be required to take additional credits in order to make up deficiencies in undergraduate course work. Students must complete a 6-credit thesis, along with an oral defense.

For the M.F.A. degree, candidates must complete a minimum of 51 credits, at least 36 of which must be at the 500 or 600 level. In some cases, students may be required to take additional credits in order to make up deficiencies in undergraduate course work. Students must complete a 12-credit M.F.A. project in their area of study, along with an oral defense.

Student Aid
Graduate assistantships available to students in this program and other forms of student aid are described in the STUDENT AID section of the *Graduate Bulletin.*

FISH AND WILDLIFE SCIENCES (F W S)

ROBERT S. BOND, *Director of the School of Forest Resources*
101 Ferguson Building
814-865-7541

Degrees Conferred: M.S., M.Agr.

Senior Members of the Graduate Faculty
Dean E. Arnold, Ph.D. (Cornell) *Adjunct Assistant Professor of Aquatic Ecology*
Robert P. Brooks, Ph.D. (Massachusetts) *Associate Professor of Wildlife Ecology*
Robert F. Carline, Ph.D. (Wisconsin) *Adjunct Associate Professor of Fish and Wildlife Science*
Jay R. Stauffer, Jr., Ph.D. (Virginia Polytech.) *Associate Professor of Fishery Science*
Gerald L. Storm, Ph.D. (Minnesota) *Adjunct Associate Professor of Wildlife Management*
Richard H. Yahner, Ph.D. (Ohio) *Associate Professor of Wildlife Management*

Associate Members of the Graduate Faculty
H. Glenn Hughes, Ph.D. (Texas A&M) *Assistant Professor of Wildlife Technology*
Michael J.. Lacki, Ph.D. (North Carolina State) *Assistant Professor of Wildlife Technology*
J. Richard Pratt, Ph.D. (Virginia Polytech.) *Assistant Professor of Aquatic Ecology*

Programs are designed to give students an understanding of the biology and management of terrestrial or aquatic wildlife species and their environments, and include training in fish and wildlife ecology, nutrition, physiology, behavior, and pathology of wildlife species; study of successional stages, land use, and management of various habitats and their impact on fish and wildlife populations; population dynamics and manipulation of animal numbers; and studies of recreational, aesthetic, and socio-economic values of fish and wildlife. Most programs of study are strengthened by including appropriate courses offered by related departments. A Ph.D. degree in Forest Resources allows specialization in fish or wildlife ecology and management at the doctoral level (see Forest Resources).

Admission Requirements
Scores from the Graduate Record Examination (GRE) are required for admission. A student may be admitted provisionally without GRE scores. Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin*.

Application materials should be submitted before February by those who want to begin in summer or fall. For admission, an applicant should have at least a 2.75 grade-point average, a 3.00 junior-senior average, and courses that are basic to the individual's field of specialization. Ordinarily these include 12 credits in communication, 12 credits in social sciences and humanities, 10 credits in quantification including calculus and statistics, 8 credits in chemistry and /or physics, 8 credits in biological sciences, and 18 credits in forest products, forestry, fish, wildlife, or related courses. GRE scores, three reference reports (forms supplied on request), and a brief statement describing the applicant's academic goals, career interests, and special qualifications are required. The best-qualified applicants will be accepted up to the number of spaces available. Exceptions to admission requirements may be made for students with special backgrounds, abilities, and interests.

Master's Degree Requirements
M.S.: In addition to Graduate School requirements, 6 credits of statistics and 2 credits of colloquium are required.

M.Agr.: Candidates select a minimum of 15 credits of graduate-level courses in departments such as Agricultural Education, Instructional Media, Journalism, Recreation and Parks, Speech Communication, English, and Theatre. Any deficiencies in a student's resource specialty, as judged by his or her advisory committee, must be remedied. An acceptable paper on a selected professional problem or a report on internship training worth 3 credits or more also is required.

Other Relevant Information
Each entering student receives individual guidance from an adviser, and later from his or her committee, in designing a program of studies and research based on his or her own interests. The student is responsible for conforming to all requirements summarized in the "Graduate Studies Handbook" of the School of Forest Resources, and for completing the degree program within a reasonable time, i.e., two years for a master's degree and three years for a Ph.D.

Student Aid

In addition to the fellowships, traineeships, graduate assistantships, and other forms of financial aid described in the STUDENT AID section of the *Graduate Bulletin*, the following awards typically have been available to graduate students in this program:

FOREST RESOURCES: JESSE ROSSITER RAPP MEMORIAL SCHOLARSHIP — Available to graduate students in the School of Forest Resources who are not holding assistantships as graduate students. Apply to the School of Forest Resources' Scholarships, Loans, and Awards Committee.

ROGER M. LATHAM MEMORIAL AWARD — Awarded to outstanding graduate students specializing in wildlife management after at least one semester in residence.

WILDLIFE (WILDL)

408. MAMMALOGY (2)
409. MAMMALOGY LABORATORY (1)
410. GENERAL FISHERY SCIENCE (3)
435. WILDLIFE ECOSYSTEMS (3)
446. WILDLIFE ECOLOGY (3)
447. WILDLIFE MANAGEMENT (3)
452. ICHTHYOLOGY (2)
453. ICHTHYOLOGY LABORATORY (2)
463. FISHERY MANAGEMENT (3)
492. WILDLIFE RESEARCH TECHNIQUES (4)
495. WILDLIFE INTERNSHIP (1-6)
496. INDEPENDENT STUDIES (1-18)
497. SPECIAL TOPICS (1-9)

529. FISH POPULATION DYNAMICS (3) Methods for analyzing fish population dynamics and their application to fisheries management. Prerequisite: a calculus course.

536. FRESHWATER FIELD ECOLOGY (3) Organisms and physical/chemical factors that affect them in the aquatic environment; basic water chemistry; identification of aquatic organisms. Prerequisite: BIOL 435.

542. (BIOL 542, ENT 542) SYSTEMATICS (3) Principles and methods of classification, phylogeny, and speciation; taxonomic techniques; analysis of species; causal interpretation of animal diversity.

546. TOPICS IN WILDLIFE POPULATION ECOLOGY (3) Topics in population ecology that have relevance to wildlife research and management.

547. WILDLIFE MANAGEMENT (3) Management, maintenance, and manipulation of wildlife populations and habitat. Prerequisite: WILDL 447.

550. WETLAND ECOLOGY AND MANAGEMENT (3) Discussions of the ecological, hydrologic, and cultural functions and values of freshwater and coastal wetlands. Prerequisite: 3 credits in ecological or hydrologic sciences.

551. WILDLIFE BIOMETRICS AND POPULATION ANALYSIS (3) Application of biometrics and mathematics to concepts and problems in wildlife ecology with emphasis on population analysis. Prerequisites: 3 credits in animal ecology and 6 credits in biometrics or statistics.

552. SYSTEMATICS AND EVOLUTION OF FISHES (3) Detailed study of the systematics, evolution, identification, and natural history of fishes. Prerequisites: BIOL 421, 452.

555. PERSPECTIVES IN WILDLIFE ECOLOGY (3) Discussion of current topics in evolutionary, community, and behavioral ecology that are applicable to wildlife research and management.

590. COLLOQUIUM (1-3)

596. INDIVIDUAL STUDIES (1-9)

597. SPECIAL TOPICS (1-9)

602. SUPERVISED EXPERIENCE IN COLLEGE TEACHING (1-3 per semester, maximum of 6)

NOTE: *See also FORESTRY.*

FOOD SCIENCE (FD SC)

LOWELL D. SATTERLEE, *Head of the Department*
111 Borland Laboratory
814-865-5444

Degrees Conferred: Ph.D., M.S.

Senior Members of the Graduate Faculty
Robert B. Beelman, Ph.D. (Ohio State) *Professor of Food Science*
Paul S. Dimick, Ph.D. (Penn State) *Professor of Food Science*
Stephanie Doores, Ph.D. (Maryland) *Associate Professor of Food Science*
Arun Kilara, Ph.D. (Nebraska) *Associate Professor of Food Science*
Manfred Kroger, Ph.D. (Penn State) *Professor of Food Science*
Gerald D. Kuhn, Ph.D. (Purdue) *Professor of Food Science*
Joseph H. MacNeil, Ph.D. (Michigan State) *Professor of Food Science*
Michael E. Mason, Ph.D. (Oklahoma State) *Adjunct Professor of Food Science*
Morris G. Mast, Ph.D. (Ohio State) *Professor of Food Science*
Lowell D. Satterlee, Ph.D. (Iowa State) *Professor of Food Science*
Marvin P. Thompson, Ph.D. (Michigan State) *Adjunct Professor of Food Science*

Associate Members of the Graduate Faculty
Richard H. Forsythe, Ph.D. (Iowa State) *Adjunct Professor of Food Science*
Edward D. Glass, Jr., Ph.D. (Penn State) *Associate Professor of Food Science*
Karen J. Miller, Ph.D. (Massachusetts) *Assistant Professor of Food Science*
Donald B. Thompson, Ph.D. (Illinois) *Assistant Professor of Food Science*

Food is directly related to human beings' health and social and political well-being. As a consequence, many well-qualified individuals will be seeking graduate education and training in this important area. The nature of graduate work leading to the M.S. and Ph.D. degrees in Food Science is not simply an extension of the undergraduate program with more courses at a higher level. Rather, it is directed toward establishing the individual as a professional leader and an independent scholar capable of tending to his or her own professional education needs for the rest of his or her life. Opportunities are available for study in the fields of biochemistry and metabolism, food chemistry (carbohydrates, lipids, proteins, enzymes), microbiology, quality control, flavor control and acceptance, product evaluation and processing. Special emphasis can be devoted to dairy, meat, plant, and poultry products, and other specific food commodities. Because of the indispensable role that research plays in the educational and cultural advancement of humanity, it is a central requirement of the Food Science program that graduate students participate in the departmental research program and develop their talents for conducting research.

Admission Requirements
Scores from the Graduate Record Examination (GRE) are required for admission. At the discretion of a graduate program, a student may be admitted provisionally for graduate study in a program without these scores. Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin*.

Students with a 3.00 junior-senior average will be considered for admission to the program, subject to limitations of physical facilities. Exceptions may be made for students with special backgrounds, abilities, and interests.

Prerequisite to graduate work is the completion of an undergraduate degree in food science, biochemistry, microbiology, or other related areas. The undergraduate program must include calculus, organic chemistry, microbiology, and general physics. Students may be admitted with deficiencies but are required to make them up without degree credit.

Students are generally admitted directly to a master's program unless they have previously earned an M.S. degree in food science or an appropriate related area; in such cases, admission can be made directly to the doctoral program by approval of the graduate program committee.

Master's Degree Requirements
The requirements for the M.S. program are detailed in the Department of Food Science's publication "Graduate Programs in Food Science." Minimum course requirements for the M.S. degree are as follows: Colloquium (FD SC 590), 1 credit; Food Science courses, 9 credits; related courses, 3 credits; Chemistry/Biochemistry courses (400 or 500 level), 6 credits, or 3 credits in Chemistry/Biochemistry and 3 credits in Mathematics/Engineering (400 or 500 level); research (FD SC 600 or 610), 6 credits.

Doctoral Degree Requirements

The requirements for the Ph.D. program are detailed in the Department of Food Science's publication "Graduate Programs in Food Science."

The communications and foreign language requirement for the Ph.D. degree must be satisfied before taking the comprehensive examination by either of the following two options:

Option A. Competence in reading, writing, and speaking one foreign language at the level normally attained by completing at least two sequence courses of undergraduate work (or 6 credits of 1G and 2G) in a language approved by the committee. This option may be satisfied by obtaining at least a grade of B in the final course of a language sequence or by passing a reading proficiency examination given by a language department.

Option B. Pass three courses from at least two of the following areas (one of the courses must be at the 400 or 500 level):

1. Technical writing
2. Speech
3. College or extension teaching
4. Logic or philosophy of science

A grade of at least B must be earned in 100-399 courses.

Minimum course requirements for the Ph.D. degree are as follows: Colloquium (FD SC 590), 2 credits; Food Science courses, 12 credits; related courses, 6 credits; Chemistry/Biochemistry courses (400 or 500 level), 9 credits, or 3 credits in Chemistry/Biochemistry and 6 credits in Mathematics/Engineering (400 or 500 level); research (FD SC 600 or 610), 6 credits.

Student Aid

Graduate assistantships available to students in this program and other forms of student aid are described in the STUDENT AID section of the *Graduate Bulletin*.

FOOD SCIENCE (FD SC)

400. Food Chemistry (3)
401. Physiology of Nutrition (3)
404. Sensory Evaluation of Foods (2)
405. Thermal Processing (2)
407. Food Toxins (2)
408. Applied Food Microbiology (2)
409. Laboratory in Applied Food Microbiology (2)
410. Chemical Methods of Food Analysis (4)
411. Managing Food Quality (2)
412. Laboratory in Managing Food Quality (1)
420. Advanced Poultry, Meat, and Fish Technology (4)
490. Undergraduate Seminar (1)
496. Independent Studies (1-18)
497. Special Topics (1-9)

505. Concepts of Product Development (2) Procedures and problems encountered in the development of new and modified food products. Idea generation through development, testing, and commercialization.

507. Food Quality, Food Standards, and Consumer Protection (2) Problems of the food industry relating to contamination and quality of food products.

508. Food Proteins (3) Properties and uses of proteins in food systems. Prerequisites: BIOCH 401, FD SC 400.

509. Enzymes and Biotechnology (3) The technological application of enzymes in foods, with special emphasis on biotechnology, production, and purification of enzymes. Prerequisites: BIOCH 401, FD SC 400.

521. Radiobiology (3) Radioactivity: its nature, interaction with matter, measurement, and quantification; the use of isotopes as tracers in biological systems.

522. Research Procedures in Food Science (3) Research problems and methods in food science, with major emphasis on food chemistry.

590. Colloquium (1-3)

596. Individual Studies (1-9)

597. Special Topics (1-9)

602. Supervised Experience in College Teaching (1-3 per semester, maximum of 6)

FOREST RESOURCES (FOR R)

ROBERT S. BOND, *Director of the School of Forest Resources*
101 Ferguson Building
814-865-7541

Degrees Conferred: Ph.D., M.S., M.Agr., M.F.R.

Senior Members of the Graduate Faculty
Dean E. Arnold, Ph.D. (Cornell) *Adjunct Assistant Professor of Aquatic Ecology*
Robert C. Baldwin, Ph.D. (Penn State) *Associate Professor of Wood Science and Technology*
Paul R. Blankenhorn, Ph.D. (Penn State) *Professor of Wood Technology*
Robert S. Bond, Ph.D. (SUNY) *Professor of Forest Resources*
Todd W. Bowersox, Ph.D. (Penn State) *Associate Professor of Silviculture*
Robert P. Brooks, Ph.D. (Massachusetts) *Associate Professor of Wildlife Ecology*
Robert F. Carline, Ph.D. (Wisconsin) *Adjunct Associate Professor of Fish and Wildlife Science*
David R. DeWalle, Ph.D. (Colorado State) *Professor of Forest Hydrology*
Henry D. Gerhold, Ph.D. (Yale) *Professor of Forest Genetics*
Russell J. Hutnik, Ph.D. (Duke) *Professor Emeritus of Forest Ecology*
Peter Labosky, Ph.D. (Virginia Polytechnic) *Professor of Wood Science and Technology*
James A. Lynch, Ph.D. (Penn State) *Associate Professor of Forest Hydrology*
Larry H. McCormick, Ph.D. (Penn State) *Associate Professor of Forest Resources*
Wayne L. Myers, Ph.D. (Michigan) *Associate Professor of Forest Biometrics*
William E. Sharpe, Ph.D. (West Virginia) *Associate Professor of Forest Resources Extension*
Robert D. Shipman, Ph.D. (Michigan State) *Professor of Forest Ecology*
William E. Sopper, Ph.D. (Yale) *Professor of Forest Hydrology*
Jay R. Stauffer, Jr., Ph.D. (Virginia Polytechnic) *Associate Professor of Fishery Science*
Kim C. Steiner, Ph.D. (Michigan State) *Associate Professor of Forest Genetics*
Gerald L. Storm, Ph.D. (Minnesota) *Adjunct Associate Professor of Wildlife Management*
Charles H. Strauss, Ph.D. (Penn State) *Associate Professor of Forest Economics*
Ben W. Twight, Ph.D. (Washington) *Associate Professor of Forest Resources*
Walter M. Tzilkowski, Ph.D. (Massachusetts) *Associate Professor of Wildlife Science*
Richard H. Yahner, Ph.D. (Ohio) *Associate Professor of Wildlife Management*

Associate Members of the Graduate Faculty
Edward S. Corbett, Ph.D. (Penn State) *Adjunct Assistant Professor of Forest Resources*
Stephen E. Fairweather, Ph.D. (Penn State) *Assistant Professor of Forest Resources Management*
Marc D. Abrams, Ph.D. (Michigan State) *Assistant Professor of Forest Ecology and Physiology*
Howard G. Halverson, Ph.D. (Arizona) *Adjunct Associate Professor of Forest Resources*
Gordon M. Heisler, Ph.D. (SUNY) *Adjunct Assistant Professor of Forest Resources*
Walter W. Johnson, Ph.D. (Oregon State) *Associate Professor of Forest Resources Extension*
Paul C. Kersavage, Ph.D. (Michigan) *Assistant Professor of Wood Technology*
Rex E. Melton, M.F. (Michigan) *Professor of Forestry*

The Doctor of Philosophy and the Master of Science degree programs are oriented toward research, education, and scientific technology in the professions of forest products, forestry, and fish and wildlife management. The Master of Forest Resources is a professional degree that emphasizes application of knowledge through managerial practices involving forest resources, industries, or the natural environments of communities and recreational areas. The Master of Agriculture is intended to enable students to develop skills as professionals in the communication of technical knowledge.

Faculty expertise, laboratories, and outdoor facilities are available to support specialization in a variety of fields. Possibilities for specialization are indicated in part by the courses listed under forest products, forestry, and wildlife, and by related courses in agricultural economics, agronomy, animal nutrition, biology, business administration, chemical engineering, computer science, ecology, eco-

nomics, entomology, environmental pollution control, environmental resource management, genetics, horticulture, industrial engineering, landscape architecture, meteorology, physiology, plant pathology, polymer sciences, recreation and parks, regional planning, or statistics.

Students in this program may elect the dual-title degree program option in Operations Research for the Ph.D. and M.S. degrees (see p. 326).

Admission Requirements

Scores from the Graduate Record Examination (GRE) are required for admission. A student may be admitted provisionally without GRE scores. Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin.*

Application materials should be submitted before February by those who want to begin in summer or fall. For admission, an applicant should have at least a 2.75 grade-point average, a 3.00 junior-senior average, and courses that are basic to the individual's field of specialization. Ordinarily, these include 12 credits in communication; 12 credits in social sciences and humanities; 10 credits in quantification, including calculus and statistics; 8 credits in chemistry and/or physics; 8 credits in biological sciences; and 18 credits in forest products, forestry, fish, wildlife, or related courses. Three reference reports (forms supplied on request) and a brief statement describing the applicant's academic goals, career interests, and special qualifications are required. The best-qualified applicants will be accepted up to the number of spaces available. Exceptions to admission requirements may be made for students with special backgrounds, abilities and interests.

Admission to the Ph.D. program in Forest Resources requires a completed master's thesis or a B.S. with research experience and publication.

Master's Degree Requirements

M.S.: In addition to Graduate School requirements, 6 credits of statistics and 2 credits of colloquium are required.

M.F.R.: A minimum of 30 graduate credits is required, of which at least 20 must be earned at an established graduate campus of the University. At least 12 credits must be in courses at the 500 level, excluding 596, and 6 credits of statistics are required. Each candidate is required to submit an acceptable paper that demonstrates an ability to apply to the professional field the knowledge gained during his or her program. Six to 9 credits will be given for this paper, which will be evaluated by the student's committee and defended in an oral exam.

M.Agr.: Candidates will elect a minimum of 15 credits of graduate-level courses in departments such as Agricultural Education, English, Mass Communications, Recreation and Parks, Speech Communication, and Theatre. Any deficiencies in a student's resource specialty, as judged by his or her advisory committee, must be remedied. An acceptable paper on a selected professional problem or a report of internship training worth 3 credits or more is also required.

Doctoral Degree Requirements

The foreign language requirement for the Ph.D. degree may be satisfied by demonstrating competence in one foreign language equivalent to passing two or three college-level courses. With approval of the doctoral committee, a student may petition the Graduate Faculty of the school for waiver of the foreign language requirement.

Postbaccalaureate course work will include courses specified for the M.S. degree plus 2 credits of colloquium. The entire program of courses tailored to the student's objectives is subject to approval of the student's committee.

The comprehensive examination will consist of an oral and written portion, the written coming first. Copies of the student's thesis research proposal should be provided to the committee before the comprehensive examination.

Other Relevant Information

Each entering student receives individual guidance from an adviser, and later from his or her committee, in designing a program of studies and research based on his or her own interests. The student is responsible for conforming to all requirements summarized in the "Graduate Studies Handbook" of the School of Forest Resources, and for completing the degree program within a reasonable time, i.e., two years for a master's degree or three years for a Ph.D.

Student Aid

In addition to the fellowships, traineeships, graduate assistantships, and other forms of financial aid described in the STUDENT AID section of the *Graduate Bulletin,* the following awards typically have been available to graduate students in this program:

Forest Resources: Jesse Rossiter Rapp Memorial Scholarship — Available to graduate students in the School of Forest Resources who are not holding assistantships as graduate students. Apply to the School of Forest Resources' Scholarships, Loans, and Awards Committee.

Roger M. Latham Memorial Award — Awarded to outstanding graduate students specializing in wildlife management after at least one semester in residence.

FOREST PRODUCTS (F P)

411. Wood-Environmental Relationships (3)
412. Wood in Structures (3)
413. The Chemistry of Wood (3)
414. Pulp and Fiber Technology (3)
415. Forest Products Manufacturing Systems and Processes (3)
416. Wood Adhesives, Finishes, and Composites (4)
422. Drying of Wood (2)
423. Deterioration and Protection of Wood Products (2)
432. Forest Products Quality Standards (3)
435. Forest Products Production Management and Marketing (3)
490. Forest Products Colloquium (1)
495. Forest Products Internship (1-6)
496. Independent Studies (1-18)
497. Special Topics (1-9)

502. Wood Fibers (3) Identification and measurement of physical and chemical characteristics of wood fibers used in paper or dissolving pulps.

511. Physical Properties of Wood and Fibers (3) Theories of moisture, diffusion, permeability, and heat transport; ultrastructure and thermal properties of wood and fibers. Prerequisite: F P 411.

513. Wood Chemistry (3) Treatment of the chemical components of wood, their distribution and reactions. Prerequisite: F P 413.

530. Forest Products Industrial Operations Analysis (2) Research methods, with emphasis on programming, simulation, and waiting line problems. Prerequisite: F P 435.

531. Mechanical Behavior of Wood (3) Time-dependent properties, theory of failure, rheologic properties, and theory of the mechanical behavior of wood and structural composites.

532. Theory of Adhesion (3) Theory of adhesion as it pertains to bonding of wood, paper-based laminates, fibers, and bonding of wood to dissimilar materials.

590. Colloquium (1-3)

596. Individual Studies (1-9)

597. Special Topics (1-9)

602. Supervised Experience in College Teaching (1-3 per semester, maximum of 6)

FORESTRY (FOR)

403. Dendrology (3)
409. Forest Tree Function and Form (2)
412. Forest Tree Improvement (3)
416. Forest Recreation (3)
421. Silviculture (3)
436. Field Problems in Forest Management (6)
440. Forest Economics and Finance (3)
450. Introduction to Operations Research (3)
455. Remote Sensing and Spatial Data Handling (3)
466. Forest Resource Management (3)
470. Watershed Management (3)
475. Principles of Forest Soils Management (3)
480. Policy and Administration (3)
495. Forestry Internship (1-6)

496. Independent Studies (1-18)
497. Special Topics (1-9)

508. Forest Ecology (3) The forest ecosystem, variations in space and time, classification, ordination techniques, dynamic aspects such as energy flow and nutrient cycling.

512. Forest Genetics (3) Qualitative and quantitative genetic principles and research methods applied in tree breeding.

517. Forest Microclimatology (3) A quantitative treatment of climate near the ground, with special reference to the role of forests and terrain. Prerequisite: PHYS 202.

518. Hydrologic Measurements (2) Selection, installation, use, and maintenance of instrumentation used in hydrologic research and watershed management. Prerequisites: FOR 470; FOR 519 or 3 credits in hydrology.

519. Forest Hydrology (3) Influence of forest cover on the disposition of precipitation and the application of hydrologic principles and techniques to forest watersheds. Prerequisites: FOR 308, C E 351.

520. Snow Hydrology (2) Role of snow and ice in the hydrologic cycle, with special emphasis on effects of forests and land use. Prerequisite: FOR 470 or 3 credits of hydrology.

521. Advanced Silviculture (3) Specific silvicultural practices for the establishment and manipulation of forest stands with respect to recent developments and research needs. Prerequisite: FOR 421.

525. Forest Land Use (3) Concepts of supply and demand for forest lands and their allocation to alternative uses. Prerequisites: FOR 466; or GEOG 405 and 3 credits in economics.

550. Multivariate Analysis in Forestry Research (3) Analysis and interpretation of research data involving several response variables. Includes computational considerations for large data sets.

555. Multispectral Remote Sensing (3) Computer analysis of data from nonimaging remote sensors as applied to mapping of natural resources and land use. Prerequisites: CMPSC 101, FOR 455.

560. Timber Management (3) Technical methods in the organization and control of the forest property for timber production.

575. Applications of Forest Economics and Finance (3) Survey of situations in forestry where business problems and particular circumstances of production, value, and costs are currently significant. Prerequisite: FOR 440.

590. Colloquium (1-3)

596. Individual Studies (1-9)

597. Special Topics (1-9)

602. Supervised Experience in College Teaching (1-3 per semester, maximum of 6)

Note: *See also WILDLIFE MANAGEMENT.*

FRENCH (FR)

RICHARD L. FRAUTSCHI, *Head of the Department*
316 Burrowes Building
814-865-1492

Degrees Conferred: Ph.D., M.A., M.B.A./M.A. in French Studies, M.P.A./M.A. in French Studies, M.S. in Business Administration/M.A. in French Studies

Senior Members of the Graduate Faculty
Gerard J. Brault, Ph.D. (Pennsylvania) *Professor of French*
Richard L. Frautschi, Ph.D. (Harvard) *Professor of French*
Thomas A. Hale, Ph.D. (Rochester) *Associate Professor of French and Comparative Literature*
Alan E. Knight, Ph.D. (Yale) *Professor of French*
Glyn Peter Norton, Ph.D. (Michigan) *Professor of French*

Associate Members of the Graduate Faculty
Robert Ariew, Ph.D. (Illinois) *Associate Professor of French*
Jeannette Danielle Bragger, Ph.D. (California) *Associate Professor of French*
Michael C. Danahy, Ph.D. (Princeton) *Associate Professor of French*
Kathryn M. Grossman, Ph.D. (Yale) *Associate Professor of French*
Christiane P. Makward, D.Litt. (Sorbonne) *Associate Professor of French*
Vera Mark, Ph.D. (Texas-Austin) *Assistant Professor of French*
Avigail Vicente, Doctorat de 3^{e} cycle (Paris) *Assistant Professor of French*
Monique Yaari, Ph.D. (Cincinnati) *Assistant Professor of French*

This program offers training in French literature, linguistics, civilization, and pedagogy.

Admission Requirements
Scores from the Graduate Record Examination (GRE) are recommended, but are not normally required. Applicants for Graduate School fellowships are required to submit GRE verbal, quantitative, and analytical test scores, or other accepted test scores approved by the dean of the Graduate School. Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin*.

The minimum requirement for admission to an advanced degree program will normally be 36 credits of postintermediate work in language and literature. Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. A brief tape recording of an original composition in French must be presented before admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

Master's Degree Requirements
A candidate for the M.A. degree (minimum of 33 credits) may select a program of study emphasizing language proficiency as well as culture and literature. A reading knowledge of a second foreign language plus oral and written examinations are required. The candidate may submit either a thesis, for which 6 research credits are normally awarded, or a paper. The M.A. degree (or equivalent) is normally a prerequisite to doctoral candidacy.

The department, in cooperation with the College of Business Administration, offers concurrent master's degree programs in French Studies and in Business Administration to provide training in both business and French studies for students who plan careers in international business. The Master of Business Administration/M.A. in French Studies program is open to graduates of accredited colleges and universities. Candidates will first be admitted as students seeking the M.B.A. or seeking the M.A. in French. Assisted by graduate advisers in both programs, students will determine the appropriate entry courses in the second program, including an intensive summer language program, prior to official acceptance by both programs as concurrent degree candidates.

The M.B.A./M.A. in French Studies program consists of a minimum of 66 credits: 39 in M.B.A. courses and 27 in graduate French language and culture courses. Required courses in business will be taken in the following sequence: tool and theory courses (M I S 531, Q B A 510, ACCTG 511, Q B A 511, B A 517, 533); functional courses (MKTG 500, 510, FIN 531); "capstone" courses (B A 555, 557, and I B 500). International business courses at the University of Nice/C.E.R.A.M./ may be substituted for B A 555. Required courses in French are language (minimum of 9 credits): FR 408, 507, 508, 510; culture and civilization (minimum of 9 credits): FR 530, 531, 595; electives (minimum of 9 graduate credits).

All concurrent degree candidates will prepare a paper in both French and English (no credits). A final oral examination may be recommended.

The M.S. in Business Adminstration/M.A. in French Studies offers specialization in an area of business administration and in French language and culture. A B.A. or B.S. degree with a minimum of 30 credits (or equivalent) in French and another 30 credits (or equivalent) in business administration/economics are prerequisites. Admission is contingent upon approval by the College of Business Administration and by the Department of French. The program consists of 54 graduate credits: 21-27 credits in business and 24-30 credits in French. Candidates will specialize in a major field of business administration. Required courses in French are FR 508, 510, 595, one graduate course in metropolitan literature, plus at least 9 elective graduate credits.

A master's thesis in both French and English is recommended. However, candidates may present a special paper (no credits) in both languages. A final oral examination will be scheduled.

The department, in cooperation with the Institute of Public Administration, offers a concurrent master's degree program in French Studies and Public Administration for students who plan careers

in public administration with an international emphasis. The M.P.A./M.A. in French Studies is open to graduates of accredited colleges and universities. Candidates may be admitted first as students seeking the M.P.A. or the M.A. in French, or they may request simultaneous admission. In either case, students will determine the appropriate introductory courses, including an intensive summer language program, prior to official acceptance by both programs as concurrent degree candidates.

The M.P.A./M.A. in French Studies program consists of a minimum of 49 credits: 24 in public administration courses and 25 in graduate French language and culture courses.

All concurrent degree students will prepare a paper. Students will consult with their graduate advisers in both programs. Using the M.P.A. program as the format, Anglophone candidates will present one of three course papers in French on a Francophone topic related to public administration. Francophone candidates will present one topic in English on an Anglophone topic related to public administration. The introduction and conclusion will be composed in both languages and manuscripts will be approved by graduate advisers in both programs.

Candidates in concurrent degree programs are urged to spend one or more semesters of study at the University of Nice/C.E.R.A.M./ in work-study programs approved for Penn State students. Candidates should consult with their graduate advisers and the Office of Foreign Studies regarding application procedures.

Doctoral Degree Requirements

The Ph.D. degree prepares candidates for careers in teaching and research at the college level. A minimum of 43 credits beyond the M.A. in French (or equivalent) is required in graduate course work. Credits must be distributed in any one of four areas of concentration: civilization, linguistics, literature, or pedagogy. Doctoral candidates must demonstrate either a four-skill proficiency, at the FS II level, in a second foreign language, or a reading knowledge of two foreign languages other than French equivalent to the 12-credit level. All doctoral students must pass a candidacy examination and a comprehensive written and oral examination.

Student Aid

Graduate assistantships available to students in this program and other forms of student aid are described in the STUDENT AID section of the *Graduate Bulletin*.

FRENCH (FR)

*121G. Fundamentals of Reading French (3) Instruction in fundamental skills required for reading expository French prose; primarily for research purposes. (This course may not be used to satisfy any baccalaureate degree requirements.) Prerequisite: senior- or graduate-standing.

*122G. Practice in Reading French (3) Development and reinforcement of basic reading skills, with emphasis on the individual student's area of research. (This course may not be used to satisfy any baccalaureate degree requirements.) Prerequisite: FR 121G.

500. History of the French Language (3) Evolution of French from its origin to the present day, with emphasis on Old French philology.

502. Introduction to French Linguistics (3) An overview of modern French linguistics, with emphasis on French syntax, including historical and theoretical linguistics.

503. French Phonology (3) Articulatory and acoustic correlates of distinctive features; synchronic dialectology; phonology in generative grammar.

504. French Morphology and Syntax (3) Principles of segmentation and decomposition; tagmemics and transformation theory; morphophonemics.

505. Syntax and Semantics of French (3) The course will examine the relationship between syntax and semantics based on French data. Prerequisite: FR 418.

507. Composition (3) Review of sentence and paragraph composition, with special emphasis on idiomatic structures. *Bragger*

508. French Business Communications (3 per semester, maximum of 6) Written and oral elements of French commerce and industry. Prerequisite: FR 510.

510. Stylistique Avancée (3) Study of rhetorical figures and expository style in prose and poetry through *dissertation* and *explication*.

511. Readings in Old French (3 per semester, maximum of 6) A survey of French literature to 1300, focusing in alternate semesters on either the twelfth or the thirteenth century. *Brault*

512. Late Medieval French Literature (3) The nondramatic literary genres of the late Middle Ages, with reference to their cultural context and social function. *Knight*

518. Medieval French Drama (3) The development of French drama from its liturgical origins to the flourishing comic theatre of the late Middle Ages. *Knight*

526. Age of Rabelais (3) Notions of literary creativity in the context of early sixteenth-century French Humanism; readings from Rabelais, Marguerite de Navarre, Scève. *Norton*

528. Age of Montaigne (3) Literary culture of Renaissance France in the context of social and political crisis; readings from Montaigne, DuBellay, Ronsard, and Sponde. *Norton*

529. Seminar in Renaissance Literature (3 per semester, maximum of 6) Intensive study of various French Renaissance writers in relation to selected artistic issues of the period. *Norton*

530. La France Contemporaine (3) A comprehensive cross-sectional view of French society and its institutions since World War II. *Bragger*

531. Francophone Culture (3 per semester, maximum of 6) Concept of francophone; French minorities in Europe and North America; role of French language in Africa, Middle East, Far East. *Hale*

533. Seventeenth-Century Prose and Poetry (3) The development of classicism; its apogee and decline as seen in the works of major prose writers and poets.

534. Molière (3) The literary achievement of Molière, the comic playwright, director, actor, and founder of the Comédie Française.

535. Seventeenth-Century French Tragedy (3) The development and triumph of tragedy as a literary genre, with special emphasis on the achievement of Corneille and Racine.

540. Voltaire and His Contemporaries (3) The artistic and philosophical evolution of Voltaire as seen in the tragedy, the philosophical tale, and poetry. *Frautschi*

541. Rousseau and His Contemporaries (3) Rousseau's rationalistic critique of civilization; his sentimental rehabilitation of the individual, family, state; Rousseau, precursor of romanticism. *Frautschi*

543. Seminar: Studies in the Enlightenment (3 per semester, maximum of 6) Discourse and thematic analysis of selected works of French Enlightenment genres: essay, drama, fiction, poetry. *Frautschi*

558. African Novel in French (3) Development of the novel in French from colonial era to independence; Africanization of genre with African verbal art forms. *Hale*

561. French Romanticism (3) The romantic movement in French literature, with emphasis upon its major exponents in prose and poetry. *Danahy*

563. French Realism (3) The realistic movement in French literature, with emphasis upon its major exponents in prose and poetry. *Danahy*

565. Seminar: Nineteenth-Century Studies (1-6) Various nineteenth-century French writers considered in relation to selected esthetic and cultural problems raised during the period. *Danahy*

569. Masters of Twentieth-Century French Literature (3-6) Major literary figures of contemporary French literature. *Makward*

570. Modern French Poetry (3 per semester, maximum of 6) Historical overview through readings from major poets since Baudelaire; introduction to basic concepts in criticism of poetry.

571. French Literary Criticism from Sainte-Beuve to Present (3) Evolution of French literary criticism from Sainte-Beuve, the "father" of modern literary criticism, to contemporary critics.

572. Seminar: Twentieth-Century French Literature (3 per semester, maximum of 6) Specialized consideration of contemporary writers; for advanced students. *Makward*

581. Theory and Techniques of Teaching French (1-6)

587. Research Techniques and Bibliography in French Language and Literature (1-3)

595. Analysis of French Civilization (3-6) French cultural aspects, other than language and literature, conducted in French with the collaboration of specialists outside the French department.

596. Individual Studies (1-9)

597. Special Topics (1-9)

602. Supervised Experience in College Teaching (1-3 per semester, maximum of 6)

FUEL SCIENCE (F SC)

ROBERT G. JENKINS, *In Charge of Graduate Programs in Fuel Science*
209 Academic Projects Building
814-865-6511

Degrees Conferred: Ph.D., M.S.

Senior Members of the Graduate Faculty
Leonard G. Austin, Ph.D. (Penn State) *Professor of Fuels and Mineral Engineering*
Michael Y. Frenklach, Ph.D. (Hebrew) *Associate Professor of Fuel Science*
Peter H. Given, Ph.D. (Oxford) *Professor Emeritus of Fuel Science*
Robert G. Jenkins, Ph.D. (Leeds) *Professor of Fuel Science*
Howard B. Palmer, Ph.D. (Wisconsin) *Professor of Energy Science*
Alan W. Scaroni, Ph.D. (Penn State) *Associate Professor of Fuel Science*
Francis J. Vastola, Ph.D. (Penn State) *Professor Emeritus of Fuel Science*
Philip L. Walker, Jr., Ph.D. (Penn State) *Evan Pugh Professor Emeritus of Materials Science*

Associate Members of the Graduate Faculty
Francis J. Derbyshire, Ph.D. (London) *Adjunct Associate Professor of Fuel Science*
Ljubisa R. Radovic, Ph.D. (Penn State) *Assistant Professor of Fuel Science*
Harold H. Schobert, Ph.D. (Iowa State) *Associate Professor of Fuel Science*

Graduate work in fuel science provides advanced professional knowledge and research opportunities in the characteristics and utilization of fuels, including their conversion to energy, to other fuels, or to other materials.

Well-instrumented research facilities are available for investigation of the chemical and physical characteristics of coals, fundamentals of coal gasification and liquefaction, flame dynamics in practical combustion systems, industrial fuel efficiency, chemistry and physics of combustion phenomena, chemical kinetics of fast gaseous reactions, formation and removal of polluting species in combustion processes, physics and chemistry of carbonaceous solids, organic geochemistry of plant-derived sediments, and catalysis. Students can plan a wide variety of programs of study to suit individual needs; coherent interdisciplinary programs are encouraged.

Admission Requirements
Scores from the Graduate Record Examination (GRE) are not required for admission into Fuel Science; however, their submission is strongly recommended. Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin*.

Applications will be accepted from persons having degrees in the basic or applied physical sciences or in engineering. Students with a 2.75 junior-senior average normally will be considered for admission. Exceptions may be made for students with special abilities, interests, or backgrounds, such as extensive industrial experience in fuels or combustion.

Degree Requirements
The nonthesis option is available for the M.S. degree.

Competency in a foreign language is not required for the Ph.D. degree. Candidates are expected to demonstrate high proficiency in both written and spoken English.

Student Aid
Graduate assistantships available to students in this program and other forms of student aid are described in the STUDENT AID section of the *Graduate Bulletin*.

*No graduate credit is given for this course.

FUEL SCIENCE (F SC)

410. Fuel Science Laboratory (3) *Scaroni*
421. Flames (3) *Frenklach*
422. Combustion Engineering (3) *Scaroni*
424. Energy and Fuels in Technological Perspective (3) *Scaroni*
430. Air Pollutants from Combustion Sources (3) *Frenklach*
431. The Chemistry of Fuels (3) *Schobert*
496. Independent Studies (1-18)
497. Special Topics (1-9)

501. Structure and Properties of Coals (3) Modern developments in coal structural studies and relationships between structure and properties of coal and coal-derived solids. Prerequisite: F SC 431. *Schobert*

502. Coal Conversion Processes (3) Review of current scientific and technological developments in coal conversion to gaseous and liquid fuels. Prerequisite: F SC 431. *Radovic*

506. Carbon Reactions (3) Current approaches to heterogeneous reactions in combustion and gasification of carbonaceous solids, including those derived from coal and petroleum sources. Prerequisite: CHEM 452. *Radovic*

512. High-Temperature Kinetics and Flame Propagation (3) Laminar and turbulent premixed and diffusion flames; gaseous detonations; rate processes in high-temperature gases. Prerequisite: F SC 421. *Frenklach*

520. Thermodynamics and Kinetics of Fuel Efficiency (3) Thermodynamics and kinetic constraints on efficiencies of thermal systems; efficiency ratios; furnace analysis; radiation in furnaces, applications and examples. Prerequisite: study of thermodynamics at the upperclass or graduate level.

522. Flame Dynamics in Combustors (3) Mixing and reaction in combustion chambers; combustor analysis; residence time distributions; perfectly and well-stirred combustors; models and experiments.

590. Colloquium (1-3)

596. Individual Studies (1-9)

597. Special Topics (1-9)

Note: *Courses in the use of X-ray diffraction, electron microscopy, spectroscopy, and electronic instrumentation in fuel science studies are listed under MATERIALS SCIENCE.*

GENETICS (GENET)

GERALD E. McCLEARN, *Chair of the Graduate Program in Genetics*
S-211 Henderson Human Development Building
814-863-2032

Degrees Conferred: Ph.D., M.S.

Senior Members of the Graduate Faculty
John E. Ayers, Ph.D. (Penn State) *Professor of Plant Pathology*
Cheston M. Berlin, M.D. (Harvard) *Professor of Pediatrics and Pharmacology*
Charles D. Boyer, Ph.D. (Penn State) *Professor of Plant Breeding and Genetics*
Donald Bryant, Ph.D. (UCLA) *Associate Professor of Microbiology*
Edward G. Buss, Ph.D. (Purdue) *Professor Emeritus of Agriculture*
Richard W. Cleveland, Ph.D. (California) *Professor of Plant Breeding*
Richard Craig, Ph.D. (Penn State) *Professor of Plant Breeding*
Eugene A. Davidson, Ph.D. (Columbia) *Professor of Biological Chemistry*
Reginald A. Deering, Ph.D. (Yale) *Professor of Biophysics*
Robert B. Eckhardt, Ph.D. (Michigan) *Associate Professor of Anthropology*
Frederick G. Ferguson, Ph.D. (Pennsylvania) *Professor of Veterinary Science*
Paul J. Fritz, Ph.D. (Auburn) *Associate Professor of Food Science*
Henry D. Gerhold, Ph.D. (Yale) *Professor of Forest Genetics*

Kenneth Goodwin, Ph.D. (Cornell) *Professor Emeritus of Poultry Science*
Paul Grun, Ph.D. (Cornell) *Professor of Cytology and Cytogenetics*
Ross C Hardison, Ph.D. (Iowa) *Associate Professor of Biochemistry*
George L. Hargrove, Ph.D. (North Carolina State) *Professor of Dairy Science*
Charles W. Hill, Ph.D. (Wisconsin) *Professor of Biological Chemistry*
R. R. Hill, Ph.D. (Cornell) *Adjunct Professor of Plant Breeding*
Anita K. Hopper, Ph.D. (Illinois) *Associate Professor of Biological Chemistry*
James E. Hopper, Ph.D. (Wisconsin) *Associate Professor of Biological Chemistry*
Edward E. Hunt, Jr., Ph.D. (Harvard) *Professor Emeritus of Anthropology and Health Education*
Richard Hyman, Ph.D. (Cal. Tech.) *Professor of Microbiology*
Samson T. Jacob, Ph.D. (Agra) *Professor of Pharmacology*
Melvin W. Johnson, Ph.D. (Wisconsin) *Associate Professor of Plant Breeding*
Marshall B. Jones, Ph.D. (California) *Professor of Behavioral Science*
C. Max Lang, D.V.M. (Illinois) *Professor of Comparative Medicine*
Harold G. Marshall, Ph.D. (Minnesota) *Adjunct Professor of Plant Breeding*
Gerald E. McClearn, Ph.D. (Wisconsin) *Evan Pugh Professor of Health and Human Development*
Bryce Munger, M.D. (Washington) *Professor of Anatomy*
Nicholas M. Nelson, M.D. (Cornell) *Professor of Pediatrics*
Richard R. Nelson, Ph.D. (Minnesota) *Evan Pugh Professor Emeritus of Plant Pathology*
Stanley R. Person, Ph.D. (Yale) *Professor of Biophysics*
Ronald D. Porter, Ph.D. (Duke) *Associate Professor of Microbiology and Molecular Genetics*
Fred Rapp, Ph.D. (Southern California) *Evan Pugh Professor of Microbiology*
C. Channa Reddy, Ph.D. (Indian Inst. of Science) *Associate Professor of Veterinary Science*
Marvin L. Risius, Ph.D. (Cornell) *Professor of Plant Breeding*
Charles P. Romaine, Ph.D. (Cornell) *Associate Professor of Plant Pathology*
Cara-Lynne Schengrund, Ph.D. (Seton Hall) *Associate Professor of Biological Chemistry*
Robert A. Schlegel, Ph.D. (Harvard) *Associate Professor of Molecular and Cell Biology*
Robert K. Selander, Ph.D. (California-Berkeley) *Eberly Professor of Biology*
Jack C. Shannon, Ph.D. (Illinois) *Professor of Horticultural Physiology*
John S. Shenk, Ph.D. (Michigan State) *Professor of Plant Breeding*
Ross Shiman, Ph.D. (California) *Associate Professor of Biological Chemistry*
Wallace C. Snipes, Ph.D. (Duke) *Professor of Biophysics*
David J. Spector, Ph.D. (Pennsylvania) *Associate Professor of Microbiology*
James L. Starling, Ph.D. (Penn State) *Professor of Agronomy*
Kim C. Steiner, Ph.D. (Michigan State) *Professor of Forest Genetics*
S. Edward Stevens, Jr., Ph.D. (Texas) *Professor of Microbiology and Molecular Biology*
William D. Taylor, Ph.D. (Manchester) *Professor of Biophysics*
Mary J. Tevethia, Ph.D. (Michigan State) *Associate Professor of Microbiology*
C. Dale Therrien, Ph.D. (Texas) *Associate Professor of Biology*
Chen-Pei David Tu, Ph.D. (Cornell) *Associate Professor of Biochemistry*
Elliot S. Vesell, M.D. (Harvard) *Evan Pugh Professor of Pharmacology, Genetics, and Medicine*
Kenneth M. Weiss, Ph.D. (Michigan) *Professor of Anthropology*
Judith Weisz, M.B., B.Chir. (London) *Professor of Obstetrics and Gynecology*
William J. White, M.S. (Penn State) *Assistant Professor of Comparative Medicine*
Lowell L. Wilson, Ph.D. (South Dakota State) *Professor of Animal Science*
James E. Wright, Jr., Ph.D. (Cornell) *Professor Emeritus of Genetics*
Ian S. Zagon, Ph.D. (Colorado) *Assistant Professor of Anatomy*
Leonard N. Zimmerman, Ph.D. (Cornell) *Professor of Bacteriology*

Associate Members of the Graduate Faculty
Guy F. Barbato, Ph.D. (Virginia Polytechnic) *Assistant Professor of Poultry Science*
Clyde C. Berg, Ph.D. (Washington State) *Adjunct Associate Professor of Agronomy*
Andrew Clark, Ph.D. (Stanford) *Associate Professor of Biology*
Karen Gottlieb, Ph.D. (Colorado) *Assistant Professor of Anthropology*
William Hendrickson, Ph.D. (Tufts) *Assistant Professor of Microbiology*
Ralph L. Keil, Ph.D. (Cornell) *Assistant Professor of Biological Chemistry*
Roger L. Ladda, M.D. (Chicago) *Professor of Pediatrics*
Dai K. Liu, Ph.D (Alabama) *Associate Professor of Pharmacology*
Andrea M. Mastro, Ph.D. (Penn State) *Associate Professor of Microbiology and Cell Biology*
Paul G. Szauter, Ph.D. (Washington) *Assistant Professor of Biological Chemistry*

The intercollege program in Genetics includes faculty of eighteen departments in the Colleges of Agriculture, Health and Human Development, the Liberal Arts, Medicine, and Science. Each student becomes associated with the adviser's department, which may provide financial support, research facilities, and office space. Applicants are encouraged to explore opportunities by contacting faculty who may be prospective advisers.

Fields available for study and research include molecular, biochemical, physiological, cellular, behavioral, developmental, pharmacological, population, and evolutionary genetics; also applications in recombinant DNA technology, genetic engineering, breeding plants or animals, and genetic counseling of humans. Organisms that are subjects of research include viruses, bacteria, fungi, insects, fish, birds, rodents, trees, agricultural plants, domestic animals, and humans. Many types of modern equipment, laboratories, field installations, and collections of various organisms are available.

Admission Requirements

Scores from the Graduate Record Examination (GRE), or from a comparable substitute examination accepted by a graduate program and authorized by the dean of the Graduate School, are required for admission. At the discretion of a graduate program, a student may be admitted provisionally for graduate study in a program without these scores. Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin*.

All application materials should be submitted by January 31 for the best chance of admission and financial aid. Applicants should have a cumulative average of at least 3.00 and appropriate courses in biology, including genetics, organic or biochemistry, statistics, other sciences, and communications. The application should include three letters of reference and a statement describing and explaining interests in genetics, types of organism and research preferred, and goals during and after graduate studies. An M.S. degree is the normal precursor to the Ph.D. degree. The M.S. may be bypassed if evidence of suitable research experience is presented, such as a refereed publication.

Master's Degree Requirements

A committee appointed for each student, with the approval of the program chair, determines specific courses, communication skills, and research acceptable for satisfying M.S. degree requirements. Course requirements include 3 credits in statistics, 3 credits per year in genetics colloquium (GENET 590 or PHARM 515), and 12 credits selected from the following courses: AGRO 411, 509, 510, 511; AN SC 422; BIOC 514; BCHEM 503; BIOL 422, 426, 427, 428, 465, 533; C MED 503; FOR 412, 512; HORT 407, 444; MICRB 505; MICRO 553, 556; M C B 430, 460, 475, 589; PED 525, 526; PHARM 515, 540; P PATH 543.

Doctoral Degree Requirements

The student's Ph.D. committee, appointed after a written and oral candidacy examination is passed, determines specific requirements for courses and research, and administers the comprehensive and final examinations. A Ph.D. major in Genetics requires 15 credits in genetics courses listed above, or equivalent transfer courses, plus 3 credits per year in genetics colloquium; a Ph.D. minor in Genetics requires 12 credits in genetics courses, plus 3 credits in statistics and 3 credits of genetics colloquium. The requirement in communication and foreign language skills is the same as that of the thesis adviser's department or program.

Other Relevant Information

When an applicant has been approved for admission by the faculty, an adviser is selected from those who indicate they are available, by mutual consent of the faculty member and the student; financial support is commonly a consideration at this time. The adviser is the chief source of guidance, advice, and liaison with the Genetics program and the associated department.

Student Aid

Graduate assistantships available to students in this program and other forms of student aid are described in the STUDENT AID section of the *Graduate Bulletin*. In most participating departments, Genetics applicants are eligible for departmental teaching or research assistantships, and other assistantships supported by grant funds of individual faculty who make these award decisions.

Applicants with a grade-point average above 3.60 and superior GRE scores are encouraged to request fellowship applications from the Graduate School before January 31.

GENETICS (GENET)

590. Colloquium (1-3)

GEOGRAPHY (GEOG)

C. GREGORY KNIGHT, *Head of the Department*
302 Walker Building
814-865-3433

Degrees Conferred: Ph.D., M.S.

Senior Members of the Graduate Faculty
Ronald F. Abler, Ph.D. (Minnesota) *Professor of Geography*
Roger M. Downs, Ph.D. (Bristol) *Professor of Geography*
Rodney A. Erickson, Ph.D. (Washington) *Associate Professor of Geography*
Peter R. Gould, Ph.D. (Northwestern) *Professor of Geography*
C. Gregory Knight, Ph.D. (Minnesota) *Professor of Geography*
Peirce F. Lewis, Ph.D. (Michigan) *Professor of Geography*
E. Willard Miller, Ph.D. (Ohio State) *Professor Emeritus of Geography*
Allan L. Rodgers, Ph.D. (Wisconsin) *Professor of Geography*
Paul D. Simkins, Ph.D. (Wisconsin) *Professor of Geography*
Frederick L. Wernstedt, Ph.D. (UCLA) *Professor Emeritus of Geography*
Anthony V. Williams, Ph.D. (Michigan State) *Associate Professor of Geography*
Lakshman S. Yapa, Ph.D. (Syracuse) *Associate Professor of Geography*
Wilbur Zelinsky, Ph.D. (California-Berkeley) *Professor Emeritus of Geography*

Associate Members of the Graduate Faculty
Robert G. Crane, Ph.D. (Colorado) *Assistant Professor of Geography*
Deryck W. Holdsworth, Ph.D. (British Columbia) *Associate Professor of Geography*
Alan M. MacEachren, Ph.D. (Kansas) *Associate Professor of Geography*
Donna J. Peuquet, Ph.D. (SUNY-Buffalo) *Associate Professor of Geography*
Brent M. Yarnal, Ph.D. (Simon Fraser) *Assistant Professor of Geography*

The faculty encourages graduate students to arrange courses of study appropriate to their individual needs and aspirations. Programs in Geography may be directed toward a career in public service, teaching and research, private industry, or one of the many other vocational opportunities open to geographers.

Students may concentrate their study on topics that fall within the special skills and interests of the faculty. Current specialties include the American landscape; behavioral geography; communications systems; the cultural and human geography of Africa, Anglo-America, Southeast Asia, and the U.S.S.R.; geographical analysis, including cartography, computer mapping, mathematical modeling, methods of geographical analysis, remote sensing, and statistical techniques; geography of the developing world; geographical theory; environmental management; industrial location; planning and regional economic development; political geography; population problems; and urban geography.

The master's program is broadly based. It is designed to provide beginning graduate students with basic training in systematic fields, geographical theory, and research techniques. Study at the doctoral level is more specialized. After admission to candidacy, doctoral students select two fields of concentration. Students may specialize in the geography of a region only if one of the faculty on their doctoral committee has research experience in that region.

Admission Requirements
Scores from the Graduate Record Examination (GRE) are required for admission. Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin*.

Students with a 3.00 junior-senior average and with appropriate course work in geography or a related discipline will be considered for admission to the M.S. program. Applicants with master's degrees from high-quality graduate programs in geography will be considered for admission to the doctoral program. The best-qualified applicants will be admitted up to the number of places that are available for new students. All students must have or must acquire competence in cartography and statistical analysis.

Baccalaureate students must earn a master's degree before they will be considered for admission to the doctoral program.

Master's Degree Requirements
The M.S. degree may be earned by completing a thesis or two papers. If the two-paper option is elected, the candidate must earn 35 credits of graduate-level work. The master's papers are usually

expanded versions of course or seminar papers that are of sufficiently high quality that they can be submitted to scholarly journals. At least one of the papers offered to fulfill the M.S. papers requirement must have been written in connection with a departmental course or seminar.

All M.S. students are required to enroll in GEOG 500 (Introduction to Geographic Research) during their first year of residence. All candidates for the M.S. must take and pass an oral qualifying examination administered by three members of the graduate faculty before completing the M.S.

Doctoral Degree Requirements

The Graduate School's communication and foreign language requirement for the Ph.D. degree shall be satisfied in a manner approved by the candidate's doctoral committee.

All doctoral students are required to enroll in GEOG 500 (Introduction to Geographic Research) during their first year of residence.

Other Relevant Information

Penn State's graduate program in Geography works with incoming students to design programs tailored to their specific interests and needs. Thus there are few formal requirements and a maximum of opportunities for students to pursue their own interests under the guidance of the faculty. Each student's work is supervised by his or her academic adviser and by a committee consisting of two additional members of the graduate faculty for M.S. students and three or four additional members for doctoral students.

Student Aid

Graduate assistantships available to students in this program and other forms of student aid are described in the STUDENT AID section of the *Graduate Bulletin.*

GEOGRAPHY (GEOG)

401. Historical Geography of North America (3) *Lewis or Zelinsky*
402. Cultural and Anthropogeography (3) *Zelinsky*
404. The American Scene: Part II (3) *Lewis*
405. Geography of Population (3) *Simkins or Zelinsky*
406. Human Use of Environment (3) *Knight*
412. The Geography of the Future (3) *Abler*
413. Behavioral Approaches to Geography (3) *Downs*
416. Low-Energy Living (3) *Knight*
420. Metropolitan Analysis (3) *Erickson*
421. Cartographic Symbolization and Design (3) *MacEachren*
422. Advanced Production Cartography (3) *MacEachren*
425. Computer-Assisted Cartography (3) *MacEachren*
427. Geography of the Soviet Union (3) *Rodgers*
432. Climatic Change and Variability (3) *Yarnal*
433. Introduction to Global Climatic Systems (3) *Yarnal*
434. Regional Physiography (3) *Lewis*
437. Satellite Climatology (3) *Crane*
440. Geography of Middle America (3) *Simkins*
441. Geography of South America (3) *Simkins*
442. Regional Systems in Europe (3) *Miller*
443. Geography of the Orient (3) *Rodgers*
444. African Resources and Development (3) *Knight*
445. Geography of Southern Asia (3) *Wernstedt*
450. Development of Geographic Thought (3) *Abler*
451. Map Interpretation (3) *Lewis*
453. Image Analysis II (3) *Eyton*
454. Spatial Analysis I (3) *Gould or Williams or Yapa*
455. Spatial Analysis II (3) *Gould or Williams or Yapa*
456. Computing for the Earth Sciences (3) *Williams*
457. Geographic Data Systems (3) *Williams*
458. Computer Mapping (3) *Williams*
459. Digital Terrain Models (3) *Crane*
460. Political Geography (3) *Williams*
470. Industrial Location and Development (3) *Rodgers*
475. Geography of Communications Systems (3) *Abler*

480. Spatial Data Structures and Algorithms (3) *Peuquet*
481. Geographic Information Systems Design and Evaluation (3) *Peuquet*
495. Internship (1-13)
496. Independent Studies (1-18)
497. Special Topics (1-9)

500. Introduction to Geographic Research (1-3)

503. Seminar in Climatology (3-6) Selected topics in climatology, emphasizing global-scale and man-climate interactions; individual and group projects. Prerequisite: GEOG 433.

504. Physical Geography Seminar (3-12) The examination of current problems and theories in physical geography through critical discussion of the literature and student research.

505. Economic Geography Seminar (3-12) The examination of current problems and theories in economic geography through critical discussion of the literature and original student research.

508. Cultural Geography Seminar (3-6) The exploration of current problems and theory in cultural geography through critical discussion of the literature and original student research.

509. Population Geography Seminar (3) Selected problems in population geography, with emphasis on analysis and presentation of data. Prerequisite: GEOG 405.

510. Analytic Cartography (3) Computer graphics, geographical matrix operations, response functions, sampling resolution, quantization, map generalization, pattern recognition, generalized spatial partitionings, and map projections. Prerequisites: GEOG 454, 455.

512. Seminar in Cartography (3-6) The exploration of current problems and theory in cartography through critical discussion of the literature and original student research. Prerequisite: 6 credits in cartography.

517. Geographic Modeling (1) Spatial modeling, mapping, and transformations of elementary geographic problems.

521. Map Symbolization and Design Theory (3) Introduction to theoretical issues in map design and symbolization, with emphasis on current research trends and practical application of research. Students who have passed GEOG 421 may not schedule this course for credit. Prerequisites: GEOG 321, 454.

525. Field Seminar in Geography (3) Intensive study of the morphology and origins of vernacular human landscapes in eastern United States and Canada. Two-week field trip. Prerequisites: GEOG 002, 102, 404.

543. Digital Image Analysis (3) Advanced techniques in digital image analysis of remotely sensed data.

580. Spatial Data Structures and Algorithms (3) In-depth examination of geographic information system components, representation and storage of spatial data, spatial algorithms, input-output considerations. Students who have passed GEOG 480 may not schedule this course for credit. Prerequisites: GEOG 456, 457.

581. Geographic Information Systems Design and Evaluation (3) Graduate-level examination of Geographic Information System and other forms of integrated spatial data system design. Prerequisite: GEOG 580.

590. Colloquium (1-3)

596. Individual Studies (1-9)

597. Special Topics (1-9)

602. Supervised Experience in College Teaching (1-3 per semester, maximum of 6)

GEOSCIENCES (GEOSC)

SHELTON S. ALEXANDER, *Head of the Department*
503 Deike Building
814-865-6711

Degrees Conferred: Ph.D., M.S.

Senior Members of the Graduate Faculty
Shelton S. Alexander, Ph.D. (Cal. Tech.) *Professor of Geophysics*
Hubert L. Barnes, Ph.D. (Columbia) *Professor of Geochemistry*
Roger J. Cuffey, Ph.D. (Indiana) *Professor of Paleontology*
Alan Davis, Ph.D. (Durham) *Professor of Geology*
Peter Deines, Ph.D. (Penn State) *Professor of Geochemistry*
David H. Eggler, Ph.D. (Colorado) *Professor of Petrology*
Terry Engelder, Ph.D. (Texas A&M) *Associate Professor of Geosciences*
Kevin P. Furlong, Ph.D. (Utah) *Associate Professor of Geosciences*
Thomas W. Gardner, Ph.D. (Cincinnati) *Associate Professor of Geology*
David P. Gold, Ph.D. (McGill) *Professor of Geology*
Earl K. Graham, Ph.D. (Penn State) *Professor of Geophysics*
Roy J. Greenfield, Ph.D. (MIT) *Professor of Geophysics*
Albert L. Guber, Ph.D. (Illinois) *Professor of Geology*
Heinrich D. Holland, Ph.D. (Columbia) *Adjunct Professor of Geosciences*
Derrill M. Kerrick, Ph.D. (Berkeley) *Professor of Petrology*
Charles A. Langston, Ph.D. (Cal. Tech.) *Professor of Geophysics*
Peter M. Lavin, Ph.D. (Penn State) *Professor of Geophysics*
Arnulf Muan, Ph.D. (Penn State) *Professor of Mineral Sciences*
Hiroshi Ohmoto, Ph.D. (Princeton) *Professor of Geochemistry*
Richard R. Parizek, Ph.D. (Illinois) *Professor of Geology*
Arthur W. Rose, Ph.D. (Cal. Tech.) *Professor of Geochemistry*
Rustum Roy, Ph.D. (Penn State) *Professor of the Solid State*
Robert F. Schmalz, Ph.D. (Harvard) *Professor of Geology*
Rudy L. Slingerland, Ph.D. (Penn State) *Associate Professor of Geology*
Deane K. Smith, Ph.D. (Minnesota) *Professor of Mineralogy*
Charles P. Thornton, Ph.D. (Yale) *Professor of Petrology*
Alfred Traverse, Ph.D. (Harvard) *Professor of Palynology*
Barry Voight, Ph.D. (Columbia) *Professor of Geology*
William B. White, Ph.D. (Penn State) *Professor of Geochemistry*

Associate Members of the Graduate Faculty
Eric J. Barron, Ph.D. (Miami) *Associate Professor of Geosciences*
Susan L. Brantley, Ph.D. (Princeton) *Assistant Professor of Geosciences*
William L. Duke, Ph.D. (McMaster) *Assistant Professor of Geology*
Lee R. Kump, Ph.D. (South Florida) *Assistant Professor of Geosciences*
John N. Louie, Ph.D. (Cal. Tech.) *Assistant Professor of Geosciences*
Michael L. Machesky, Ph.D. (Wisconsin-Madison) *Assistant Professor of Geochemistry*
Stephen J. Mackwell, Ph.D. (Australian National) *Assistant Professor of Geosciences*
Norman H. Suhr, M.S. (Chicago) *Associate Professor of Geochemistry*

There are three graduate degree programs to which a student may be admitted: Geochemistry and Mineralogy, Geology, and Geophysics. Faculty affiliations with individual graduate programs are listed under Geochemistry and Mineralogy, Geology, and Geophysics. Transfer from one of these majors to another is possible with the approval of the program chair, the department, and the Graduate School.

A wide range of faculty interests and exceptional laboratory facilities provide an extensive variety of areas of specialization in which students may choose their course work and research topics. In addition to a variety of computing facilities, students have access to laboratories for research on the petrography and petrology of igneous, metamorphic, and sedimentary rocks, including coal and organic sediments; complete palynological processing and microscopy facilities; rock preparation and rock mechanics laboratories; high-temperature and high-pressure/high-temperature equipment for dry or hydrothermal geochemical experiments and solid-state geophysical measurements; mass spectrometers and ancillary equipment for isotope analysis; a seismic observatory, ultrasonic model and paleomagnetism laboratories, and field equipment for seismic, electrical, magnetic, and gravity surveys; data and facilities for remote sensing of earth resources; laboratories and field facilities for the study of the hydrogeology and geochemistry of natural waters; an X-ray laboratory for single-crystal and powder methods at low and high temperatures; and coastal marine laboratories in Virginia. The

department and the Mineral Constitution Laboratories are equipped for both classical methods of chemical analysis and modern instrumental methods, such as atomic absorption, emission and absorption spectroscopy, transmission and scanning electron microscopy, and electron and ion microprobe analysis. The department also maintains a predoctoral research program in cooperation with the Geophysical Laboratory of the Carnegie Institution in Washington.

Admission Requirements

Scores from the Graduate Record Examination (GRE) are normally required for admission to the graduate programs of the Department of Geosciences. Exceptions must be approved by the department and the graduate program. Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin.*

For admission, applicants generally are expected to have a bachelor's degree in some branch of the natural or physical sciences, engineering, or mathematics. An applicant also is expected to have completed standard introductory courses in geosciences, chemistry, physics, and mathematics through integral calculus, plus 15 credits of intermediate-level work in one or a combination of these subjects. Greater than minimal preparation within these limits may be required in chemistry and mineralogy for the Geochemistry and Mineralogy major; in geology and biology for the Geology major; and in mathematics and physics for the Geophysics major. Applicants who have taken somewhat less than the indicated minimum in these subjects may be admitted but must make up their deficiencies concurrently with their graduate studies. Students with special backgrounds, abilities, and interests whose undergraduate grade-point average in courses pertinent to geosciences is below a 3.00 will be considered for admission only when there are strong indications that a 3.00 average can be maintained at the graduate level.

Students are admitted both to the M.S. and Ph.D. degree programs. A student may work toward a Ph.D. degree without first earning a master's degree. If this option is desired, the student must arrange the scheduling of a candidacy evaluation no later than the end of the second semester of residence at Penn State. The petition to bypass the M.S. degree must be approved by the program chair and the student's research and academic adviser(s).

Students with an M.S. degree are generally admitted to a Ph.D. program, except where it appears advisable to the admissions committee that the student receive an additional M.S. degree in the particular program to which admission is sought. The applicant will be informed of the decision prior to admission.

Faculty Advisers

Upon arrival students will be advised initially either by the program chair or someone designated by him or her. Before the end of the first academic year of residence in the department, the student is expected to develop specific academic and research interests so that an appropriate permanent academic and research adviser may be chosen. The academic adviser and the research adviser are usually the same person, except when the research adviser is not a member of the faculty of the student's graduate program. In such a case, a faculty member in the student's graduate program will serve as the academic adviser. Upon request from a student to the program chair, or for other reasons, it is possible to change advisers if the reassignment best serves the interests of the student and the department.

Student Aid

Graduate assistantships available to students in this program and other forms of student aid are described in the STUDENT AID section of the *Graduate Bulletin.* In addition, several graduate fellowships are available for students enrolled in the individual graduate programs in the Geosciences department.

Programs of study are planned to require no more than two years (four semesters plus one summer session in the Geophysics program) for the M.S. degree and three additional years, or five years total, for the Ph.D. degree. A student transferring to the department with the M.S. degree should plan on four additional years. Financial support from teaching or research assistantships or from fellowships is not awarded beyond those limits except in unusual cases.

GEOSCIENCES (GEOSC)

401. Geologic Perspectives of Industrial Activities (2)
402. (METEO 476) Natural Disasters Seminar (2)
403. Geological Aspects of Environmental Problems (3)
404. Geology of the Solar System (3)
409. Crystallography and Optical Crystallography (3) *Smith and Thornton*

415. Geochemistry (3) *Deines*
416. Stable and Radioactive Isotopes in Geosciences: Introduction (3) *Ohmoto and Deines*
419. Introduction to Organic Geochemistry (3)
420. (BIOL 420) Paleobotany (3)
421. Introduction to Coal Petrology (3) *Davis*
422. Coal Measure Geology (3) *Davis*
423. (BIOL 423) Introductory Palynology (4) *Traverse*
425. Fossils (3) *Cuffey*
426. Paleoecology (3) *Cuffey*
427. (BIOL 427) Evolution (3) *Cuffey and Traverse*
430. Petrology (5)
434. Volcanology (3) *Thornton*
438. Biogenic Sedimentation (3) *Guber*
*439. Stratigraphy (3)
440. Marine Geology (3) *Barron*
442. Evolution of Coastlines (3)
445. Coastal Geology (4) *Guber*
451. Economic Geology (3) *Gold and Rose*
452. Introduction to Hydrogeology (3) *Parizek*
454. Geology of Oil and Gas (3) *Schmalz*
457. Geochemical Exploration (3) *Rose*
461. Geology of North America (3)
*462. Drainage Basin Analysis (3) *Gardner*
465. Structural Geology (3) *Engelder*
466. Mechanics of Geological Materials (3) *Voight*
*470. Introduction to Field Geology (3) *Gold*
*471. Field Studies in North America (3)
*472. Field Geology (7-8)
473. Topographic Maps and Aerial Photographs (1)
482. Geophysical Well Logging (3)
484. Geophysical Surveying (3) *Lavin*
485. Applied Seismology (4) *Langston and Lavin*
486. Potential Fields (2-4) *Greenfield and Lavin*
487. Analysis of Time Series (4) *Lavin*
488. Theoretical and Numerical Methods in Geophysics (3) *Alexander*
489. Dynamics of the Earth (4) *Furlong*
490. Geological Sciences Seminar (1-6 per semester)
496. Independent Studies (1-18)
497. Special Topics (1-9)

511. (MATSC 511) Instrumental Techniques Applied to Materials and Mineral Sciences Problems (1-7) See units A through G for description.

Unit A. (MATSC 511A) Powder X-Ray Diffraction (1) Compound identification, lattice parameter measurement, and other applications of the powder diffraction method.

Unit B. (MATSC 511B) Transmission Electron Microscopy (1) Principles and practice of transmission electron microscope operation. Students undertake individual projects.

Unit C. (MATSC 511C) Spectroscopy (1) Emission spectrographic analysis of powders and atomic absorption analysis of solutions.

Unit D. (MATSC 511D) Electron Microprobe Analysis (1) Qualitative and quantitative elemental analysis of microvolumes within solids. Emphasis on individual student project.

Unit E. (MATSC 511E) Scanning Electron Microscopy (1) Principles and practice of scanning electron microscope operation. Students undertake individual projects.

Unit F. (MATSC 511F) Absorption Spectroscopy (1) Techniques and instrumentation for UV-visible-near-infrared absorption and reflection, IR and far IR absorption, and Raman scattering spectroscopy.

*This course includes from one to several field trips for which an additional charge will be made.

Unit G. (MATSC 511G) Analytical Electron Microscopy (1) Modern analytical electron microscope techniques: scanning transmission electron microscopy; electron energy loss spectroscopy; energy dispersive analysis of X-rays. Prerequisite: MATSC (GEOSC) 511B.

593. (ANTH 593, BIOL 593, ENT 593, INTAG 593) Tropical Field Studies (Organization for Tropical Studies) (8) An intensive field course concentrating on field problems, experimental design, and data analysis in tropical habitats. Prerequisite: approval by the Committee on Tropical Studies.

597. Special Topics (1-9)

602. Supervised Experience in College Teaching (1-3 per semester, maximum of 6)

GEOCHEMISTRY AND MINERALOGY (G M)

PETER DEINES, *In Charge of Graduate Programs in Geochemistry and Mineralogy*
204 Deike Building
814-865-7152

Degrees Conferred: Ph.D., M.S.

Senior Members of the Graduate Faculty
Hubert L. Barnes, Ph.D. (Columbia) *Professor of Geochemistry*
Peter Deines, Ph.D. (Penn State) *Professor of Geochemistry*
David H. Eggler, Ph.D. (Colorado) *Professor of Petrology*
Kevin P. Furlong, Ph.D. (Utah) *Associate Professor of Geosciences*
Derrill M. Kerrick, Ph.D. (Berkeley) *Professor of Petrology*
Arnulf Muan, Ph.D. (Penn State) *Professor of Mineral Sciences*
Hiroshi Ohmoto, Ph.D. (Princeton) *Professor of Geochemistry*
Arthur W. Rose, Ph.D. (Cal. Tech.) *Professor of Geochemistry*
Rustum Roy, Ph.D. (Penn State) *Professor of the Solid State*
Deane K. Smith, Ph.D. (Minnesota) *Professor of Mineralogy*
Charles P. Thornton, Ph.D. (Yale) *Professor of Petrology*
William B. White, Ph.D. (Penn State) *Professor of Geochemistry*

Associate Members of the Graduate Faculty
Susan L. Brantley, Ph.D. (Princeton) *Assistant Professor of Geosciences*
Lee R. Kump, Ph.D. (South Florida) *Assistant Professor of Geosciences*
Michael L. Machesky, Ph.D. (Wisconsin) *Assistant Professor of Geochemistry*
Stephen J. Mackwell, Ph.D. (Australian National) *Assistant Professor of Geosciences*
Norman H. Suhr, M.S. (Chicago) *Associate Professor of Geochemistry*

A general description of the Department of Geosciences is given on page 216. Areas of specialization in the Geochemistry program include phase equilibria; element distribution and affiliations; isotope geochemistry; geochemical exploration; cosmochemistry; high-temperature and high-pressure geochemistry; environmental geochemistry; ore-forming processes; igneous, sedimentary, and metamorphic petrology; experimental petrology and mineralogy; crystallography; crystal chemistry; X-ray mineralogy; clay mineralogy; and ore mineralogy.

Admission Requirements
See the ADMISSION REQUIREMENTS section under the description of the Department of Geosciences.

Master's Degree Requirements
All incoming students to the program meet with a faculty committee prior to registration to aid in effective advising and structuring of a suitable course program for individual students. Specific course requirements for individual students are established at this time.

A candidate for the M.S. degree may, after consultation with his or her adviser, elect to take either the thesis or the nonthesis option. There is no distinction between these options with regard to level or quality of the research required; the thesis or written report must be defended in an oral examination.

All requirements for a master's degree, whether satisfied on the University Park Campus or elsewhere, must be met within six years or a period spanning seven consecutive summers.

Doctoral Degree Requirements

All graduate students in the Geochemistry and Mineralogy program who want to be admitted to Ph.D. candidacy must take a candidacy examination. With the approval of his or her adviser, a student may petition to combine the defense of the M.S. thesis or paper and the Ph.D. candidacy evaluation into one oral examination.

The comprehensive examination in the Geochemistry and Mineralogy program consists of both written and oral portions. The written examination is six to eight hours in duration and covers the areas of geochemistry, mineralogy, petrology, and general geosciences. The oral examination, which usually lasts three hours, probes in depth the knowledge in the areas of the student's specialization.

The Ph.D. foreign language requirements may be met by fulfilling any one of the following criteria: (1) obtain a minimum average grade of 2.50 in two 3-credit courses in each of two languages taken at any accredited college, or obtain a minimum grade of B in the second course in both languages; (2) pass a lower-level reading proficiency examination in each of two languages, administered by the foreign language departments at any accredited college; (3) obtain a minimum average grade of 2.50 in a 12-credit sequence of courses in one language taken at any accredited college, or obtain a minimum grade of B in the last course in such a sequence; (4) pass a higher-level reading proficiency examination in one language, administered by the Department of Geosciences; (5) fulfill option 1 for one language and option 2 for a second language; or (6) fulfill option 1 or option 2 for one language and pass one of the graduate foreign language seminars offered by the Department of Geosciences.

A student is required to complete the program within seven years from the date of acceptance as a candidate. When a period of more than five years has elapsed between the passing of the comprehensive examination and the completion of the program, the student is required to pass a second comprehensive examination before the final examination will be scheduled.

Student Aid

Graduate assistantships available to students in this program and other forms of student aid are described in the STUDENT AID section of the *Graduate Bulletin*.

GEOCHEMISTRY AND MINERALOGY (G M)

501. Research Frontiers Seminar (1) Current research problems and activities in geochemistry and mineralogy. Pass/fail grades are used for evaluation. *Staff*

503. (MATSC 503) Kinetics of Materials Processes (3) Introduction to application of transition state theory and mass transfer to the kinetics of materials and mineral processes. Prerequisites: MATH 250, CHEM 451; G M 521 or MATSC 501.

512. (MATSC 512) Principles of Crystal Chemistry (3) Relation of structure to ionic size and nature; influence of pressure and temperature on structure; chemical-structural defects, crystalline solutions, phase-transitions. *Roy*

*515. Ore Petrology (3) Optical and hardness measurements and phase equilibria as used in identification and interpretation of texture of ore minerals. *Barnes*

518. Stable Isotope Geochemistry (3) Theory of isotope fractionation mechanisms; its application to a wide range of problems in the earth and planetary sciences. *Deines*

520. Phase Equilibria (2-3) Thermodynamic and geometrical analysis of phase equilibria in oxide and mineral systems at atmospheric and elevated pressures. *Eggler, Muan*

521. Mineral Equilibria (3) A thermodynamic treatment of minerals and their reactions under geochemically important conditions of temperature and pressure. Prerequisite: CHEM 451. *Muan, Kerrick*

522. Geochemistry of Aqueous Systems (2-3) Ionic and molecular equilibria related to stabilities and solubilities of minerals, with applications to ground water, sea water, and hydrothermal fluids. Prerequisites: CHEM 451-452. *Barnes, Brantley, Machesky*

523. Sedimentary Geochemistry (2) Kinetics and thermodynamics of low-temperature processes in sediments. Applications to weathering processes, natural waters, deposition of sediments, and diagenesis. Prerequisite: GEOSC 430. *Brantley, Kump*

*Offered alternate years.

*524. (MATSC 524) Vibrational Spectra of Materials and Minerals (3) Infrared and Raman spectroscopy of materials, with applications of mineralogy, geochemistry, ceramics, and glass research. *White*

*525. Electronic Properties of Minerals (3) Application of spectroscopy to mineralogy — crystal field, E.P.R., N.M.R., and Mossbauer spectral evidence of ordering, element distribution, and stabilities. *White*

*527. Advanced Mineralogy (3) Detailed study of the crystal structures and crystal chemistry of minerals. *Smith*

530. Topics in Hydrothermal Geochemistry (2) Methods of obtaining data; their evaluation and use in the quantitative treatment of hydrothermal systems, primarily by thermodynamic methods. Prerequisites: G M 521, 522. *Barnes*

*532. Crystal Structure Analysis (2) Experimental techniques for, and the theory of crystal structure determination. Prerequisite: GEOSC (MATSC) 408. *Smith*

*535. (MATSC 535) Geometrical Crystallography (3) Derivation of lattices, types, point groups, and space groups; and group theory applied to crystallography and spectroscopy. *Ryba, Smith*

540. Ore Deposits I (3) Geochemistry and geology of ore deposits formed by igneous and high-temperature hydrothermal processes. Prerequisite: GEOSC 451. *Staff*

541. Ore Deposits II (3) Geochemistry and geology of ore deposits formed by low-temperature hydrothermal, sedimentary, metamorphic processes; continuation of G M 540. Prerequisite: G M 540. *Staff*

550. Igneous and Metamorphic Petrology (4) Analysis of controls of mineralogy, elemental, and isotopic compositions of igneous rock series and of metamorphic rocks. Prerequisite: GEOSC 430. *Eggler, Kerrick*

551. Magmatic Systems (3) Application of theory and experimental results to the origin of igneous rocks and associated hydrothermal fluids. Prerequisites: G M 520, 521.

552. Igneous Petrology (3) Analysis of igneous rocks of the earth and other planetary bodies. Prerequisites: G M 520, 550. *Eggler*

553. Metamorphic Petrology (3) Seminar with directed reading on controls and processes in the evolution of metamorphic rocks. Prerequisites: G M 520, 521. *Kerrick*

560. Kinetics of Geological Processes (3) General development of the kinetic theory of crystal growth, diffusion, irreversible thermodynamics, and heterogeneous reactions needed for geosciences and related fields, with applications to current problems. Prerequisites: CHEM 451, G M 521. *Brantley, Machesky*

590. Colloquium (1-3)

596. Individual Studies (1-9)

597. Special Topics (1-9)

*Offered alternate years.

GEOLOGY (GEOL)

ALBERT L. GUBER, *In Charge of Graduate Programs in Geology*
303 Deike Building
814-865-3836

Degrees Conferred: Ph.D., M.S.

Senior Members of the Graduate Faculty
Roger J. Cuffey, Ph.D. (Indiana) *Professor of Paleontology*
Alan Davis, Ph.D. (Durham) *Professor of Geology*
Terry Engelder, Ph.D. (Texas A&M) *Associate Professor of Geosciences*
Kevin P. Furlong, Ph.D. (Utah) *Associate Professor of Geosciences*
Thomas W. Gardner, Ph.D. (Cincinnati) *Associate Professor of Geology*
David P. Gold, Ph.D. (McGill) *Professor of Geology*
Albert L. Guber, Ph.D. (Illinois) *Professor of Geology*
Richard R. Parizek, Ph.D. (Illinois) *Professor of Geology*
Robert F. Schmalz, Ph.D. (Harvard) *Professor of Geology*
Rudy L. Slingerland, Ph.D. (Penn State) *Associate Professor of Geology*
Alfred Traverse, Ph.D. (Harvard) *Professor of Palynology*
Barry Voight, Ph.D. (Columbia) *Professor of Geology*

Associate Members of the Graduate Faculty
Eric J. Barron, Ph.D. (Miami) *Associate Professor of Geosciences*
Susan L. Brantley, Ph.D. (Princeton) *Assistant Professor of Geosciences*
William L. Duke, Ph.D. (McMaster) *Assistant Professor of Geology*
Lee R. Kump, Ph.D. (South Florida) *Assistant Professor of Geosciences*
John N Louie, Ph.D. (Cal. Tech.) *Assistant Professor of Geosciences*
Stephen J. Mackwell, Ph.D. (Australian National) *Assistant Professor of Geosciences*

A general description of the Department of Geosciences is given on page 216. The Geology faculty offers programs in paleoclimatology and paleooceanography, stratigraphy, paleontology, sedimentation, paleobotany, palynology, regional and structural geology, geomorphology, ground water geology, engineering geology, marine geology and chemical oceanography, coal geology, coal petrology, geology of metallic and nonmetallic deposits, and economic geology.

Admission Requirements
See the ADMISSION REQUIREMENTS section under the Department of Geosciences.

Master's Degree Requirements
The master's degree requirements of the Geology program are those of the Graduate School. A candidate for the M.S. degree may, after consultation with his or her adviser, elect to defend either a thesis or a paper written in the format of the journal, agency report, bulletin, etc., to which it is to be submitted. There is no distinction between these options with regard to level or quality of the research required. The thesis or written report must be defended in an oral examination.

Doctoral Degree Requirements
All graduate students in the Geology program who want to be admitted to Ph.D. candidacy must take a formal candidacy examination administered by a standing committee of three members representing the major disciplines (biogeology, structural and economic geology, and stratigraphy and surface process) plus the potential thesis adviser and another faculty member appointed by the program chair. The candidacy examination consists of an oral examination of about three hours' duration, and upon the discretion of the committee, it may be followed by an additional oral or written examination. Incoming students with a master's degree must take this examination before the end of their second semester in residence. Students who earn a master's degree at Penn State must take the candidacy examination within four months of defending their M.S. thesis.

The comprehensive examination of the Geology program consists of an oral examination administered by the student's doctoral committee. Normally, this examination lasts about three hours and probes in depth the knowledge in the areas of the student's specialization. At the discretion of the committee it may be followed by a written examination.

The Ph.D. foreign language requirements may be met by completing 6 credits of foreign language courses with an average grade of B or better.

Student Aid

In addition to the fellowships, traineeships, graduate assistantships, and other forms of financial aid described in the STUDENT AID section of the *Graduate Bulletin*, the following awards typically have been available to graduate students in this program:

CHARLES E. KNOPF, SR., MEMORIAL SCHOLARSHIP — $800 per academic year.

SCHOLTEN, WILLIAMS AND WRIGHT FELLOWSHIP — Stipend variable.

SOHIO. FIELD RESEARCH FUND — Stipend, $7,000 per year.

GEOLOGY (GEOL)

502. CARBONATES IN THE MARINE ENVIRONMENT (3) Ancient carbonate rocks and recent carbonate sediments, with emphasis on modern field and laboratory methods and a multidisciplinary approach. *Schmalz*

503. PALEONTOLOGY (1-6 per semester, maximum of 9) Morphology and distribution of significant fossil groups; sampling, preparation, and applications to biostratigraphy, evolution, paleoecology, sedimentation, and petrography. *Cuffey*

504. HISTORY AND FOUNDATIONS OF GEOLOGY (2-4) Theoretical aspects of geology: spatiotemporal organization of matter, dynamic processes, sequential development; basic patterns and history of scientific thought.

505. QUANTITATIVE PHYSICAL SEDIMENTOLOGY (3) Principles of fluid mechanics and mathematical modeling; their use in describing sediment transport, sedimentary structure, and sedimentary environments. Prerequisite: GEOSC 330. *Slingerland*

506. SEDIMENTS OF THE WORLD (2-3 per semester, maximum of 6) Evolution of sediments from Archean to recent; relationship of sedimentation to geotectonism; kratonic and geosynclinal sediments; cyclicity.

508. CLASTIC DEPOSITIONAL ENVIRONMENTS (3) Readings, group discussions, and field work on processes and sedimentary responses of common rock-forming environments. Prerequisite: GEOSC 439. *Duke*

509. (MN EC 509) GEOLOGY AND ECONOMICS OF THE CONSTRUCTION MATERIALS (3) Occurrence, origin, and marketing of the mineral materials used by the construction industry. Economic and geologic evaluation of actual deposits. *Schenck and Gold*

510. (MN EC 510) GEOLOGY AND ECONOMICS OF THE INDUSTRIAL MINERALS (3) Occurrence, origin, and marketing of the industrial minerals and evaluation of deposits. Chemical and ceramic raw materials emphasized. *Schenck and Gold*

524. COAL PETROLOGY (1-6) Microscopy, source materials, coalification, constitution, classification of peats, lignites, bituminous coal, anthracite. *Davis*

526. (BIOL 526) PROBLEMS IN PALYNOLOGY (1-6) Individual research projects in various aspects of palynology, especially palynostratigraphy and paleoecological palynology. Prerequisite: GEOSC (BIOL) 423. *Traverse*

541. ENVIRONMENTAL GEOLOGY (1-3) A multidisciplinary study of the impact of man-induced stress on the environment. Prerequisite: GEOSC 452. *Parizek*

542. QUANTITATIVE METHODS IN HYDROGEOLOGY (1-4) Investigation of groundwater systems and resources, emphasizing both the practical use and limitations of modeling techniques. Prerequisite: GEOSC 452. *Parizek*

545. GLACIAL GEOLOGY (3) Glaciers: their characteristics, causes, deposits, landforms, effects in periglacial regions. *Parizek*

546. PRINCIPLES OF PHOTOGEOLOGY (3) Use of aerial photographs and mosaics in structural, geomorphic, and rock distribution studies and in compilation of maps. Prerequisites: GEOSC 462, 465. *Gold and Gardner*

551. DYNAMIC STRUCTURAL GEOLOGY AND GEOTECTONICS (3-6) Phenomena of fracturing, faulting, folding; stress and (finite) strain analysis, physical and analytical models; deformational environments; tectogenesis and orogenesis. *Voight*

555. Advanced Structure and Petrofabrics (1-3) Macroscopic and mesoscopic recognition, measurement, and interpretation of small-scale rock structures and mineral orientation patterns in deformed rocks. *Gold*

562. Fluvial Geomorphology (3) Process-oriented analysis of the variables of the fluvial system, emphasizing man's interaction. *Gardner*

563. Hillslope Evolution (3) Analysis of hillslope processes and forms. Topics include evolutionary theories, climate and tectonic influence, stability-instability, and human impact. Prerequisite: introductory course in geomorphology. *Gardner*

571. Field Problems in Appalachian Geology (3) Geologic history of the central Appalachians as deduced from field studies. *Slingerland*

590. Colloquium (1-9)

596. Individual Studies (1-9)

597. Special Topics (1-9)

GEOPHYSICS (GPHYS)

EARL K. GRAHAM, *In Charge of Graduate Programs in Geophysics*
403 Deike Building
814-865-2622

Degrees Conferred: Ph.D., M.S.

Senior Members of the Graduate Faculty
Shelton S. Alexander, Ph.D. (Cal. Tech.) *Professor of Geophysics*
Kevin P. Furlong, Ph.D. (Utah) *Associate Professor of Geosciences*
Earl K. Graham, Ph.D. (Penn State) *Professor of Geophysics*
Roy J. Greenfield, Ph.D. (MIT) *Professor of Geophysics*
Charles A. Langston, Ph.D. (Cal. Tech.) *Professor of Geophysics*
Peter M. Lavin, Ph.D. (Penn State) *Professor of Geophysics*

Associate Members of the Graduate Faculty
John N. Louie, Ph.D. (Cal. Tech.) *Assistant Professor of Geosciences*
Stephen J. Mackwell, Ph.D. (Australian National) *Assistant Professor of Geosciences*

A general description of the Department of Geosciences is given on page 216. In the Geophysics program students may specialize in seismology, exploration geophysics, rock and mineral physics, tectonics and geodynamics, potential field methods, geophysical data processing methods, geophysical remote sensing from space, planetary physics, and computational modeling of dynamical geophysical processes.

Admission Requirements
Scores from the Graduate Record Examination (GRE), or from a comparable substitute examination accepted by a graduate program and authorized by the dean of the Graduate School, are required for admission. At the discretion of a graduate program, a student may be admitted provisionally for graduate study in a program without these scores. Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin*.

For admission to the Geophysics program, the general admission standards of the geosciences department (GEOSC) must be met. In addition, an applicant is expected to have had courses in mathematics through differential equations; a standard introductory course each in physics, chemistry, and earth sciences; and at least 16 credits of intermediate-level work in any one or a combination of these subjects. Students may be accepted with a previous degree in geophysics, physics, mathematics, engineering, earth sciences, or a closely allied field.

Master's Degree Requirements
Every graduate student is required to have passed the following courses or their equivalent either as a graduate student or as an undergraduate: GEOSC 465, Structural Geology; GEOSC 485, Applied Seismology; GEOSC 486, Potential Fields; and GEOSC 489, Dynamics of the Earth.

Every M.S. candidate must include in his or her major a minimum of four advanced (500-level) courses in geophysics exclusive of seminars, research, or independent study. At least 9 credits of course work must be taken in subjects other than geophysics, including at least one physics and one mathematics course at the intermediate or advanced level. Students must maintain a B average in all formal course work, excluding seminars and research. E MCH 524A and/or 524B may be used in meeting the foregoing physics and mathematics requirements. In addition, each M.S. student must take 1 credit of Seminar (GPHYS 590) each year and 6 credits of Independent Study (GPHYS 596 or 600) in his or her M.S. program. Students must also demonstrate ability in computer programming.

As part of the M.S. program each student is required to complete a thesis or written report. The latter is expected to conform to the same high scientific standards as a thesis. The thesis or written report must be defended in an oral examination.

Doctoral Degree Requirements

Admission to Ph.D. candidacy is determined by a formal oral candidacy examination. In addition, before being admitted to Ph.D. candidacy in the Geophysics program, the student must be accepted by a member of the Geophysics faculty as a thesis advisee.

Each student seeking Ph.D. candidacy is required to take and pass at Penn State, either formally or by examination, the following six (18 credits total) candidacy courses: GEOSC 465, Structural Geology; GEOSC 489, Dynamics of the Earth; two intermediate- or advanced-level geophysics courses (excluding GEOSC 482 and 484); one physics and one mathematics course at the intermediate or advanced level. (E MCH 524A and/or 524B are acceptable for this latter requirement.)

Courses that have these specified courses as prerequisites or equivalent courses taken elsewhere (if approved) may be substituted for any of the above requirements. Ph.D. thesis research credits (600 level) should not be scheduled until after a favorable candidacy evaluation. Research credits taken before candidacy will not be accepted as part of the work for the Ph.D., except for a maximum of 6 credits that leads to an acceptable master's thesis or report.

In addition to the foregoing candidacy course requirements, a Ph.D. student majoring in Geophysics must take in his or her graduate program at least 12 credits of 500-level course work in Geophysics aside from seminars, research, and independent study, and at least 21 credits in other subjects. If approved, equivalent courses taken elsewhere may be substituted for these requirements. Doctoral students in the Geophysics program also must take 1 credit of Seminar (GPHYS 590) each year.

The candidacy and comprehensive examinations of the Geophysics program are oral examinations. An additional written part of the comprehensive examination may be required by the candidate's doctoral committee. No candidate may take either the candidacy or the comprehensive examination more than twice. A final oral defense of the Ph.D. thesis is required.

There is no foreign language requirement in the Geophysics Ph.D. program.

Student Aid

In addition to the fellowships, traineeships, graduate assistantships, and other forms of financial aid described in the STUDENT AID section of the *Graduate Bulletin,* the following awards typically have been available to graduate students in this program:

AMOCO FOUNDATION MASTERS FELLOWSHIP IN GEOPHYSICS — Available to an M.S. graduate student with interests in exploration geophysics; $6,000 per academic year.

ARCO FELLOWSHIP IN GEOPHYSICS — $8,000 per academic year.

CHEVRON FELLOWSHIP IN GEOPHYSICS — $7,000 per year, plus tuition.

MOBIL FELLOWSHIP IN GEOPHYSICS — $6,000 per academic year.

TENNECO FELLOWSHIP IN GEOPHYSICS — $11,000 per academic year.

GEOPHYSICS (GPHYS)

504. MULTIDIMENSIONAL SIGNAL PROCESSING (3) Methods of signal enhancement and detection for problems in one-, two-, or three-space dimensions and multichannel arrays of time series. Applications covered include potential fields, remote sensing imagery, and seismic arrays.

506. MATERIAL PROPERTIES AND THE CONSTITUTION OF EARTH (3) Application of the properties of materials to the composition and physical state of Earth's crust, mantle, and core.

507A. SEISMOLOGY (3) Basic theory; seismic methods for inferring structure of planetary interiors; observational techniques; seismic event location, magnitude, and damage potential.

507B. Seismology (3) Advanced wave propagation theory; mathematical representation of seismic sources; inversion theory; computational methods.

508. Tectonics (3) Seminar in the cause and nature of the principal deformations of Earth.

515. Advanced Exploration Geophysics (2-6) Special topics and new developments in exploration geophysics; coverage (2 credits each) in gravity and magnetic, electrical, electromagnetic, or seismic methods.

517. Computational Methods in Geophysics (3) Practical methods of modeling geophysical phenomena for geologic structures; data analysis techniques; systematic inversion of geophysical data; special mathematical approximations.

521. Thermal State of the Earth (3) Analytical and numerical solutions to Earth-related heat conduction and convection problems; geothermal energy; Earth's heat flow and temperature.

590. Colloquium (1-3)

596. Individual Studies (1-9)

597. Special Topics (1-9)

GERMAN (GER)

ERNST SCHÜRER, *Head of the Department*
S-323 Burrowes Building
814-865-5481

Degrees Conferred: Ph.D., M.A., M.Ed.

Senior Members of the Graduate Faculty
Ernst A. Ebbinghaus, Ph.D. (Philipps University, Marburg) *Professor of German and Comparative Literature*
W. LaMarr Kopp, Ph.D. (Penn State) *Professor of German*
Rio Preisner, Ph.D. (Charles University, Prague) *Professor of German*
Ernst I. Schürer, Ph.D. (Yale) *Professor of German*
Vickie L. Ziegler, Ph.D. (Yale) *Associate Professor of German*

Associate Members of the Graduate Faculty
Thomas O. Beebee, Ph.D. (Michigan) *Assistant Professor of Comparative Literature and German*
Barton W. Browning, Ph.D. (California) *Associate Professor of German*
Manfred E. Keune, Ph.D. (Michigan State) *Associate Professor of German*
Gerhard F. Strasser, Ph.D. (Brown) *Associate Professor of German and Comparative Literature*

Programs of study with major emphasis upon literature, philology, culture, or the teaching of German lead to advanced degrees.

Admission Requirements
Scores from the Graduate Record Examination (GRE) are desirable. Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin*.

Minimum qualifications for admission include 30 undergraduate credits in German beyond the intermediate level. Provision is made, however, for admission with limited deficiencies. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. Requirements for admission to the M.Ed. degree program include 18 credits in education and related psychology. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

Master's Degree Requirements
Work for the master's degree can be completed in two semesters of full-time study or, if the student is a graduate assistant, in three to four semesters. The degree may be earned either by writing a thesis,

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Note: *See the GEOSCIENCES listing for 400-level Geophysics courses. Courses in the use of X-ray diffraction, electron microscopy, and spectroscopy in geophysical studies are listed under MINERALOGY.*

recommended for students applying for doctoral candidacy, or by submitting an essay to the department and taking additional 500-level German courses in lieu of 6 credits of thesis research.

Course work in the M.A. program includes bibliography and research techniques, history of the German language, and seminars providing intensive study of selected authors or topics. Practical experience in supervised teaching is required for all graduate degrees. For the final examination, the student chooses three areas of specialization.

In the M.Ed. program, the student may select courses in the history of the German language, linguistics, German culture and civilization, advanced German stylistics, and educational theory and policy in addition to courses in German literature. Appropriate courses taken in the College of Education can lead to certification for secondary schools in Pennsylvania. Requirements for admission to the M.Ed. degree program include 18 credits in education and related psychology.

Doctoral Degree Requirements

For the Ph.D. degree there is no specific requirement. Upon passing a doctoral candidacy examination, the student selects those advanced courses and seminars that will help him or her prepare for the doctoral comprehensive examinations. The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of two foreign languages.

Other Relevant Information

Penn State's Pattee Library maintains excellent holdings for research, including the Allison-Shelley Collection of Anglica, Americana, and Germanica; extensive collections of German Baroque literature on microfilm and of emblem books; and twentieth-century German literature, especially the works of German writers in exile since 1933. The Seminar Library in Burrowes Building serves the needs of students with reference works, German journals, newspapers, and an extensive textbook collection.

Student Aid

In addition to the fellowships, traineeships, graduate assistantships, and other forms of financial aid described in the STUDENT AID section of the *Graduate Bulletin*, the following awards typically have been available to graduate students in this program:

Exchange Fellowship at Kiel University and the Pädagogische Hochschule Flensburg — Available to graduate students in German and other fields for a full academic year. Students must have a good command of German. Stipend is approximately $450 per month plus tuition.

Edwin Erle Sparks Dissertation Fellowship in the Humanities — Available to a doctoral candidate in one of the following graduate programs: classics, comparative literature, English, French, German, history, linguistics, philosophy, religious studies, Slavic languages and literatures, Spanish, and speech communication; stipend $8,040 plus tuition. Apply to department before February 1.

Edwin Erle Sparks Fellowship in the Humanities (8) — Available to beginning and continuing graduate students in one of the following graduate programs: classics, comparative literature, English, French, German, history, linguistics, philosophy, religious studies, Slavic languages and literatures, Spanish, and speech communication; stipend $6,740 plus tuition. Apply to department before February 1.

The above fellowships include grants-in-aid covering all tuition charges. Advanced graduate students who do not hold fellowships or assistantships also may apply for graduate grants-in-aid which cover tuition charges.

Graduate assistantships require teaching, under supervision.

GERMAN (GER)

401. Advanced Conversation and Composition (4)
408. Advanced German Business Communications (3)
411. The Teaching of German (3)
412. Structural Analysis of Modern German (3)
430. History of the German Language (3)
440. Advanced Studies in German Culture and Civilization (3)
443. (C LIT 443) Literary Relations of Germany with England and America (3-9)
445. The Vikings (3)
452. Literature of the Renaissance (3)

460. Literature of the Baroque (3)
461. Literature of the Enlightenment (3)
462. Literature of the Late Eighteenth Century (3)
470. Goethe (3)
471. Schiller (3)
472. Romanticism (3)
480. Realism (3)
481. Early Twentieth Century (3)
482. Recent German Literature (3)
495. Internship (3-9)
496. Independent Studies (1-18)
497. Special Topics (1-9)
499. Foreign Study — German (3-6) Advanced studies in German language, literature, and culture. Prerequisite: any 300-level course in German.

*001G. Elementary German for Graduate Students (3) Designed for students preparing to satisfy language requirements for advanced degrees.

*002G. Elementary German for Graduate Students (3) Continuation of GER 001G, with opportunity for reading in special fields.

500. Bibliography and Research Techniques (3) Introduction to tools and methods of research, designed for students preparing for independent investigation of problems in German literature and language.

501. Seminar in German Conversation and Composition (3) Advanced study of German conversation and composition, with emphasis on syntax, style, and idiomatic constructions.

508. Seminar in German Business Communications (3) Practices and problems in the administration of German business organizations. Writing letters, reports, and other types of business communications.

520. Introduction to Middle High German (3) Descriptive and historical grammar; readings in simple Middle High German texts.

521. Readings in Middle High German (3) Intensive reading in Middle High German literature, especially of the *Blütezeit*. Prerequisite: GER 520.

522. Old High German (3) Essentials of grammar, with special treatment of the High German sound shift and of ablaut and umlaut; reading of works written before A.D. 1100.

523. Gothic (3) Introduction to historical and comparative Germanic grammar; emphasis on the Gothic language and texts. Suitable for advanced students in English.

525. Old Icelandic (3) Introduction to Old Icelandic grammar; readings in Old Icelandic prose. Suitable for advanced students in English.

531. Seminar in Medieval German Languages and Literatures (3-6)

540. Seminar in German Culture and Civilization (3) Examination of special problems in German culture and civilization.

541. Seminar in the Literature of the Reformation and Baroque (3-6)

551. Seminar in the Literature of the Enlightenment and the Age of Goethe and Schiller (3-6)

561. Seminar in Post-Idealistic Literature (3-6)

571. Seminar in Modern German Literature (3-6)

581. Seminar in Literary Genres (3-12) Special studies in the German lyric, drama, short story, and novel.

*No graduate credit is given for this course.

591. Seminar in German Literary Criticism (3)

596. Individual Studies (1-9)

597. Special Topics (1-9)

602. Supervised Experience in College Teaching (1-3 per semester, maximum of 6)

HEALTH EDUCATION (HL ED)

RICHARD W. ST. PIERRE, *Chair of the Department*
19 White Building
814-863-0435

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Senior Members of the Graduate Faculty
Larry K. Olsen, Dr.P.H. (UCLA) *Professor of Health Education*
Richard W. St. Pierre, Ed.D. (North Carolina) *Associate Professor of Health Education*
Mary E. Taylor, Ph.D. (Cornell) *Associate Professor of Health Education*
Edward W. Wickersham, Ph.D. (Wisconsin) *Associate Professor of Biology*

Associate Member of the Graduate Faculty
Collins O. Airhihenbuwa, Ph.D. (Tennessee) *Assistant Professor of Health Education*

Health education is a profession that complements several health-related fields such as medicine, health administration, and public health. Students may emphasize either a school, community, or university health aspect of sport research, or worksite health education focus, and choose from a wide variety of interdisciplinary course offerings in health and related fields. The M.S. and Ph.D. degrees are academic degrees with a strong emphasis on research and the scientific and theoretical principles underlying effective health education. The M.Ed. and D.Ed. degrees are professional degrees emphasizing applied research on the problems of supervision, administration, and teaching. A nonthesis option is available for the M.Ed. degree. All programs of study require research experience to enable the student to analyze problems, assess information, draw logical conclusions, and apply research findings.

The faculty has diverse research interests related to such areas as health behavior, health promotion, program evaluation, sexuality, smoking, alcohol, teaching methods, stress, dying and death, smokeless tobacco, AIDS, and international health issues.

Admission Requirements
Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION and the APPLICATION AND ADMISSION sections of the *Graduate Bulletin*.

A junior-senior grade point average of 3.00 is required for admission into the master's program. A doctoral applicant is expected to have completed the Miller Analogies Test (MAT), have at least a 3.30 academic average for completed master's work, and have at least one year of full-time professional experience in health education or a related field. All applicants are further evaluated on the basis of related course work, academic achievements, work experience, technical writing ability, and letters of recommendation. Doctoral applicants also are evaluated on the basis of the MAT score. All students must demonstrate proficiency in the use of the English language. Exceptions to admission requirements may be made for students with special backgrounds, abilities, and interests.

Master's Degree Requirements
A minimum of 30 graduate credits is required for the completion of the master's degree, although many students choose to take additional course work. A 6-credit thesis is required for the M.S. option, and a 3-credit master's paper is required for the M.Ed. degree. The M.S. thesis is expected to be research-based with a strong theoretical orientation. The M.Ed. paper is usually of an applied nature and directed toward contributing to knowledge in the areas of teaching, or educational administration and supervision. Projects such as a scholarly paper, a publishable article, an annotated bibliography, a curriculum package, or a comprehensive student survey on a particular health issue are acceptable for the M.Ed. paper.

Candidates for the M.S. and M.Ed. degrees are required to take an intermediate-level statistics

course and a research methods course, and must have at least 12 credits of 500-level courses (M.Ed. — 15 credits of 500-level courses). All students must take, or must have taken, an advanced course in health education methods and must take at least 9 additional credits in health education. At least 6 credits must be taken in supporting areas outside of the department.

Doctoral Degree Requirements

Admission to candidacy. Once admitted to the doctoral program, all students must take a written and oral candidacy examination, which is usually given before the end of the first semester that the student is on campus. The examination covers five major areas of master's level preparation for health education: (1) scientific and theoretical foundations; (2) psychological and sociological foundations; (3) methodological and curricular approaches; (4) research and evaluation techniques; and (5) content specific to the career orientation of the candidate. The committee that evaluates the candidacy exam may (1) admit the student to candidacy, (2) require specific course work or other additional study to aid the student with deficiencies, (3) require the student to retake the examination at a later date, or (4) deny admission to candidacy for a doctoral degree.

Required course work. At least 50 percent of all course work must be at the 500 level. Both D.Ed. and Ph.D. students must take at least one advanced statistics course and must be able to demonstrate competency in the use of the computer and statistical program packages. In addition, doctoral students must give evidence of basic prerequisite course work, experience, or independent study in the following areas: sexuality, drug use/abuse, nutrition, humans and disease, physiology/growth and development, advanced health education methods, communications, behavior science/psychology, and research methods. Students must arrange, with their adviser, to correct any deficiencies.

Ph.D. requirements. Although not required by the department, Ph.D. students are encouraged to have a minor area of study. The communication and foreign language requirement for the Ph.D. may be satisfied by one of two methods: (1) by demonstrating intermediate knowledge of one foreign language and the selection of courses from appropriate communication areas; or (2) by selecting designated courses from areas including research design, statistics, and computer applications.

D.Ed. requirements. Students seeking the D.Ed. degree are required to have a minor in an acceptable field of study. The minor area adviser must be selected from the graduate faculty in the minor field of study. The minor consists of a minimum of 15 credits of course work related to the minor field and approved by the minor area adviser.

Comprehensive examination. Both Ph.D. and D.Ed. candidates are required to take a written and oral comprehensive examination once their course work is substantially completed. The examination is prepared by the student's doctoral committee and covers all phases of the student's doctoral work.

Other Relevant Information

Students are assigned academic advisers upon admission to the department. However, students may change advisers once they have the opportunity to get to know the faculty. Students are responsible for asking faculty members to serve on their master's or doctoral committee. All students in residence are expected to become involved with the research and teaching activities within the department. A variety of enriching activities are made available to motivated students who want to improve their teaching and research skills, or who want to get experience in working with schools or health-related agencies.

Student Aid

Graduate assistantships available to students in this program and other forms of student aid are described in the STUDENT AID section of the *Graduate Bulletin.* Students who want to apply for graduate assistantships offered through the department must complete departmental forms. These forms are available through the department office.

HEALTH EDUCATION (HL ED)

403. Emergency Medical Technology (4)
404. Emergency Medical Technology Instructor (2)
405. Administrative Aspects of Athletic Training (3)
408. Injury Control (3)
415. Education for Wellness (3)
416. Evaluation of Health Education and Health Promotion Programs (3)
420. Development of Stress Management Programs for Health Education (3)
421. Integrating Health Education into the School Program K-12 (3)
432. Safety Education (3)

433. Principles and Methods of Teaching Safety Education (3)
435. Introduction to Therapeutic Modalities (3)
436. Application of Physical Therapy Modalities (2)
443. Alcohol Education (3)
446. Human Sexuality as a Health Concern (3)
456. Advanced Techniques in School Community Health Education (3)
457. Consumer Health Education (3)
495. Health Education Practicum (3-10)
496. Independent Studies (1-18)
497. Special Topics (1-9)

501. World Health Promotion (3) Analysis of the various health problems that affect humans throughout the world. Emphasis will be placed on personal health issues.

511. (ANTH 511) Health Implications in the Growth and Development of School Children (3) Child growth and development emphasis for teachers; medical inspection and examination; preschool program; early habit formations; behavior problems.

513. (ANTH 513) Health Implications in Maturity and Aging (3) Changes in the human body in maturity and aging; mechanisms of physiologic aging; implications for health and preventive medicine. Prerequisite: HL ED (ANTH) 511.

521. Problems in School Health Administration (3) Critical concerns in the development and coordination of curriculum, policies, and evaluation of health education and services in school systems. Prerequisite: HL ED 456.

530. (EXSCI 530, RC PK 530) Research Techniques in Health and Physical Education and Recreation (3) Research techniques, including methods, research design, techniques for data collection, as applied to relevant problems in the health education field.

552. Current Health Education Issues (3) Analysis of scientific and political foundations of current issues within health education tasks, with emphasis on research and action implications.

560. Curriculum Development in Health Education (3) The analysis and development of curriculum with specific application to health, health behaviors, and health education. Prerequisite: HL ED 456.

590. Colloquium (1-3)

595. Internship (1-6) Supervised off-campus experience in a school, university, community or corporate based health promotion program. Prerequisite: prior approval of proposed assignment by instructor.

596. Individual Studies (1-9)

597. Special Topics (1-9)

602. Supervised Experience in College Teaching (1-3 per semester, maximum of 6)

HEALTH PLANNING AND ADMINISTRATION (H P A)

STANLEY P. MAYERS, JR., *Department Head*
LARRY D. GAMM, *Professor-in-Charge, Graduate Studies*
115 Human Development
814-863-2859

Degrees Conferred: M.H.A.

Senior Members of the Graduate Faculty
Frederick R. Eisele, Ph.D. (NYU) *Associate Professor of Social Policy*
Larry Gamm, Ph.D. (Iowa) *Associate Professor of Health Administration*
Stuart H. Mann, Ph.D. (Case Western Reserve) *Professor of Operations Research*
Marshall W. Raffel, Ph.D. (Victoria) *Professor of Health Planning*
Bruce C. Stuart, Ph.D. (Washington State) *Associate Professor of Health Planning and Administration*
Charles E. Yesalis III, Sc.D. (Johns Hopkins) *Professor of Health Planning and Administration*
Lucy C. Yu, Ph.D. (Michigan) *Associate Professor of Health Planning and Administration*

Associate Members of the Graduate Faculty
Diane Brannon, Ph.D. (Cornell) *Assistant Professor of Health Planning and Administration*
J. Gregory Carroll, Ph.D. (Cornell) *Associate Professor of Health Planning and Administration*
Stanley P. Mayers, Jr., M.D. (Pennsylvania) *Professor of Health Care Planning*

The Master of Health Administration (M.H.A.) degree program is designed to prepare individuals for administrative positions in various health service organizations such as hospitals, nursing homes, home health organizations, health maintenance organizations, mental health organizations, public health departments, and ambulatory care facilities. The program curriculum combines a primary focus on health administration with additional content covering the nature of human health and illness, the structure of the health services system, health policy, and health services research and communication skills.

The M.H.A. program encourages selection of field and functional emphases within health administration. Field emphases include hospital administration, long-term care administration, ambulatory care administration, and other areas. Functional emphases include strategic planning and marketing, accounting and finance, information systems, management science, human resources management, and health services research. The M.H.A. student is encouraged to draw upon faculty expertise from several academic programs in pursuit of these emphases.

Admission Requirements
Scores from the Graduate Record Examination (GRE) or from a comparable substitute examination accepted by the graduate program and authorized by the dean of the Graduate School, are required for admission. At the discretion of the graduate program, a student may be admitted provisionally for graduate study in a program without these scores. Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin.*

A junior-senior grade point average of 3.00 or better, a combined verbal and quantitative GRE score of 1000 or better, and a well-considered statement of career goals are major criteria for admission. Some work experience in health services is desirable. Deficiencies in one or two areas may be offset by significant strength in the remaining areas. A personal interview may be required.

Master's Degree Requirements
The M.H.A. degree requirements include three preprogram requirements and a minimum of 51 credits of graduate course work. Before entering, or by the end of the first semester, students must have successfully completed an undergraduate course in microeconomics, introductory financial accounting, and introductory statistics. These courses will not be counted toward the M.H.A. degree. The M.H.A. program office can provide information on different vehicles for meeting these preprogram requirements.

The M.H.A. degree is designed to be completed within twenty-one months of full-time study. The 51-credit M.H.A. program comprises 18 credits in health administration (including credits in managerial accounting, financial management, and management information systems), 12 credits focused on the health system and health and human illness, 6 credits in health services research, and 15 credits (including a 3-credit master's paper) within which students may pursue a particular emphasis. Except for students with a significant health administration experience, a ten- to twelve-week internship during the summer between the first and second years is required.

Student Aid
Graduate assistantships available to students in this program and other forms of student aid are described in the STUDENT AID section of the *Graduate Bulletin.*

HEALTH PLANNING AND ADMINISTRATION (H P A)

401. Comparative Health Systems (3)
410. Principles of Public Health Administration (3)
420. Environmental Health (3-6)
430. Principles of Health Planning (3)
431. Health Planning Methods (3)
433. Administration of Hospital and Health Services Systems (3)
440. Principles of Epidemiology (3)
442. Long-Term Care Management (3)
445. (ECON 445) Health Economics (3)
447. Financing Health Care (3)

450. Health Services Regulatory Policies (3)
455. Strategic Planning and Marketing for Health Services (3)
496. Independent Studies (1-18)
497. Special Topics (1-9)

503. (CSP D 503) Understanding Organizational Behavior (3) A systematic application of the principles of organizational behavior to understanding professional roles in human services organizations.

504. (CSP D 504) Interorganizational Relations (3) Interorganizational concepts and their application to analysis of policies, programs, and service delivery concerns involving health and human services organizations. Prerequisite: CSP D 503.

505. (CSP D 505) Processes of Planned Change (3) Exploration of diagnostic and intervention strategies employed in planned change in health and human services organizations and programs.

522A. (CSP D 522A) Health Care Technology: Processes of Health and Disease (1) A review of the processes of health and disease, measurements, diagnostic criteria, and intervention strategies.

522B. (CSP D 522B) Health Care Technology: The Technologies of Prevention (1) Health promotion and disease prevention from a technologic perspective, including physiologic, behavioral, and social/institutional technologies.

522C. (CSP D 522C) Health Care Technology: The Technologies of Therapy and Rehabilitation (1) Technologic intervention on disease processes and rehabilitation: implications for clinical care, institutional management, and health sector planning.

524. (CSP D 524) Management of Health Services Organizations (3) A systematic study of the roles of health services managers and the organizational and environmental context within which they work. Prerequisites: H P A 503, 504.

525. (CSP D 525) Hospital and Health Services Administration (3) A study of decision making in hospitals and health organizations; the process of decision making, incorporating various techniques and strategies. Prerequisites: H P A 520, 524, 535, Q B A 511.

527. (CSP D 527) Approaches to Health Planning (3) A systematic exploration of approaches to health planning and an application of health planning techniques. Prerequisite: CSP D 531.

531. (CSP D 531) Health Problem Analysis (3) Logic of empirical inquiry in study of community problems in health; integration of theory and practice, technical data, and values.

535. (CSP D 535) Financial Management in Health Institutions (3) The financial environment of health institutions; financial aspects of management decision making; emphasis on revenue sources, budgeting, and cost control.

536. (CSP D 536) Health Law (3) The legal process as it applies to the health administrator, health organization, medical provider, and patient. Prerequisite: H P A 520.

596. (CSP D 596) Individual Studies (1-9)

597. (CSP D 597) Special Topics (1-9)

HIGHER EDUCATION (HI ED)

ROBERT M. HENDRICKSON, *In Charge of Graduate Programs in Higher Education*
130 Willard Building
814-863-2690

Degrees Conferred: Ph.D., D.Ed., M.Ed.

Senior Members of the Graduate Faculty
Robert M. Hendrickson, Ed.D. (Indiana) *Associate Professor of Education*
Sebastian V. Martorana, Ph.D. (Chicago) *Professor of Education*
Kathryn McDaniel Moore, Ph.D. (Wisconsin) *Professor of Higher Education*
Kenneth P. Mortimer, Ph.D. (California) *Professor of Higher Education*
William Toombs, Ph.D. (Michigan) *Professor of Education*

Associate Members of the Graduate Faculty
James E. Fairweather, Ph.D. (Stanford) *Assistant Professor of Education*
Roger L. Geiger, Ph.D. (Michigan) *Associate Professor of Education*
G. Gregory Lozier, D.Ed. (Penn State) *Affiliate Associate Professor of Education*
William G. Tierney, Ph.D. (Stanford) *Assistant Professor of Education*

The graduate program in Higher Education has as its goal the preparation of individuals who will pursue careers and exert leadership in postsecondary education as administrators, faculty, or researchers in the nation's colleges and universities and in a variety of public and private agencies and associations in the United States and other nations. With emphasis on the systematic study of higher education, the program builds on the scholarly and scientific disciplines offered throughout the University and applies these studies to the professional functions and responsibilities that its graduates will assume, and to the knowledge of the field of higher education. The program is concerned with four broad areas of higher education study and with three areas of special emphasis: academic programs and evaluation, organization and administration, and perspectives on higher education policy and practice.

With mounting awareness of the changes occurring in various academic and professional fields, of the need for higher education reform, and of the need for improved articulation among the various levels of education, higher education faculty cooperates with other departments of the University to offer a number of courses and seminars for graduate students interested in pursuing a minor in higher education.

Admission Requirements
Scores from the Graduate Record Examination (GRE), or from a comparable substitute examination accepted by a graduate program and authorized by the dean of the Graduate School, are required for admission. At the discretion of a graduate program, a student may be admitted provisionally for graduate study in a program without these scores. Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin*.

The best-qualified applicants will be accepted up to the number of spaces that are available for new students. The Miller Analogies Test (MAT) has been accepted by the program and authorized by the dean of the Graduate School for use in admission decisions as a substitute for the GRE. Applicants with a standardized test score above 60 on the MAT, or a total Verbal and Quantitative score above 1100 on the GRE, and with a junior-senior average of 3.00 and a graduate average of 3.50 are usually admitted to the Ph.D. and D.Ed. programs. Applicants with a junior-senior average of 2.70, a graduate average of 3.20, and an MAT score of 50 or a GRE total score of 1000 but with special backgrounds, abilities, and interests also may be admitted to the D.Ed. program with only the baccalaureate degree, but they will earn the master's degree en route.

Master's Degree Requirements
M.Ed. students are required to write a master's paper in lieu of a thesis in addition to the required 30 credits of course work. A minimum of 18 credits in course work must be taken at the 500 level, with at least 15 credits being in higher education courses.

Doctoral Degree Requirements
Ph.D. students should have a master's degree in one of the social sciences or a related discipline and experience in a college or university or education-related agency. Work needed to supplement this discipline background will have to be made up in residence at Penn State. At least 12 credits in research methods and/or statistics are required of Ph.D. students. D.Ed. students who do not have previous experience in higher education are expected to acquire the equivalent of one year of experience prior to receiving their D.Ed. degree. During the comprehensive examination, in addition to being examined in their area of specialization, all Ph.D. and D.Ed. students will be examined in five common higher education areas: history and philosophy, curriculum and instruction, organization and administration, higher education clientele, and research methodology.

Student Aid
In addition to the fellowships, traineeships, graduate assistantships, and other forms of financial aid described in the STUDENT AID section of the *Graduate Bulletin,* a limited number of graduate assistantships, in addition to those available through the Higher Education program, are available to Higher Education majors with special competencies through the Center for the Study of Higher Education, 325 Pond Laboratory, The Pennsylvania State University, University Park, PA 16802.

HIGHER EDUCATION (HI ED)

545. Higher Education in the United States (3) Introduction to the educational context and major organizational and academic characteristics of postsecondary education; analysis of issues and future trends.

546. College Teaching (2-3) Principles involved in teaching at the college level; effective use of teaching aids; criteria used in evaluation.

548. Curriculums in Higher Education (2-3) Various types of curriculums and philosophies underlying them; ways in which curriculums are developed; elective versus required courses; evaluation of achievement.

549. (ADTED 549) Community Junior College and the Technical Institute (2-3) Distinctive contributions to meeting the need for postsecondary education; development, functions, curriculum and instruction, government, administration, and finance.

550. Education for the Professions (3) Professions: changing concepts and practices; social control and responsibilities; professional schools and university values; continuing professional education; academic professions; assessment.

552. Administration in Higher Education (3) Philosophy of administration; principles of scientific management and their application in colleges and universities; case studies of administrative problems. Prerequisite: courses or experience in higher education.

554. The History of American Higher Education (3) An examination of the development of American higher education against the background of influential social, political, economic, and intellectual issues.

556. Higher Education Students and Clientele (3) Characteristics of higher postsecondary education students and other clientele; changes during postsecondary education years and during college; educational challenges and responses.

558. Curriculum Design and Evaluation in Higher Education (3) Processes and methods of higher education curriculum design, implementation, and evaluation; appropriate resources and their practical application; illustrative case studies. Prerequisite: HI ED 548.

562. Administration in Higher Education II (3) Application of social science theory and research to postsecondary education organizations and administration; use of research in administrative practice. Prerequisite: HI ED 552.

590. Colloquium (1-3)

595. Internship in Higher Education (1-9) Supervised experience in administrative offices, in research, on instructional teams, and in college teaching.

596. Individual Studies (1-9)

597. Special Topics (1-9)

HISTORY (HIST)

CHARLES D. AMERINGER, *Head of the Department*
601 Liberal Arts Tower
814-865-1367

Degrees Conferred: Ph.D., D.Ed., M.A., M.Ed.

Senior Members of the Graduate Faculty
Charles D. Ameringer, Ph.D. (Fletcher Sch. Law & Dipl.) *Professor of Latin American History*
Eugene N. Borza, Ph.D. (Chicago) *Professor of Ancient History*
Ira V. Brown, Ph.D. (Harvard) *Professor Emeritus of American History*
William J. Duiker III, Ph.D. (Georgetown) *Professor of East Asian History*
Gerald G. Eggert, Ph.D. (Michigan) *Professor of American History*
George M. Enteen, Ph.D. (George Washington) *Associate Professor of History*
John B. Frantz, Ph.D. (Pennsylvania) *Associate Professor of History*
Paul B. Harvey, Jr., Ph.D. (Pennsylvania) *Associate Professor of History*
Warren W. Hassler, Jr., Ph.D. (Johns Hopkins) *Professor Emeritus of American History*

Robert J. Maddox, Ph.D. (Rutgers) *Professor of American History*
Dan P. Silverman, Ph.D. (Yale) *Professor of European History*
E-tu Zen Sun, Ph.D. (Radcliffe) *Professor of Chinese History*

Associate Members of the Graduate Faculty
Priscilla F. Clement, Ph.D. (Pennsylvania) *Associate Professor of History*
Gary S. Cross, Ph.D. (Wisconsin-Madison) *Assistant Professor of History*
Gary W. Gallagher, Ph.D. (Texas-Austin) *Assistant Professor of History*
Richard L. Garner, Ph.D. (Michigan) *Associate Professor of History*
Lori D. Ginzburg, Ph.D. (Yale) *Assistant Professor of History*
Arthur E. Goldschmidt, Jr., Ph.D. (Harvard) *Associate Professor of History*
Cyril E. Griffith, Ph.D. (Michigan State) *Associate Professor of History*
Ronald W. Linker, Ph.D. (Johns Hopkins) *Associate Professor of History*
Sally A. McMurry, Ph.D. (Cornell) *Assistant Professor of History*
Jackson J. Spielvogel, Ph.D. (Ohio State) *Assistant Professor of History*
Phillip E. Stebbins, Ph.D. (Ohio State) *Associate Professor of History*
James Ross Sweeney, Ph.D. (Cornell) *Associate Professor of History*

The department offers graduate instruction, research opportunities, and practicums appropriate for a wide variety of careers: teaching history and/or social studies at all levels, positions with museums and archives, and careers in government, the foreign service, and applied history. Students desiring post-baccalaureate instruction prior to beginning professional school often find training in history useful. Both lecture-discussion courses and research seminars are offered in the following areas of history: Ancient, Medieval, Modern European, British, Russian and Soviet, American, African, Middle Eastern, East Asian, and Latin American.

Admission Requirements
Scores from the Graduate Record Examination (GRE), or from a comparable substitute examination, are required for admission. A student may be admitted provisionally for graduate study in a program without these scores. Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin*.

To be considered for admission, applicants must also submit college transcripts that show (1) course work in European history from ancient through modern times and in American history from the Age of Columbus to the present, and (2) a minimum junior-senior grade-point average of 3.00 and better than 3.00 in all college-level history courses. Exceptions to the minimum grade-point averages may be made for students with special backgrounds, abilities, and interests. Applicants also must have three persons familiar with their competence in history send letters of recommendation on their behalf. Applicants should submit directly to the history department a specimen of their methodological competence (i.e., undergraduate history thesis, seminar paper, or equivalent research paper) as proof of ability in research skills.

Applicants who already hold a master's degree in history will be admitted to the doctoral program. All others will be admitted to the master's program.

Master's Degree Requirements
Candidates for the M.A. or M.Ed. degree must earn a minimum of 30 credits of graduate-level work. Candidates select one of the areas of history listed above as their area of specialization and must pass a comprehensive examination in that area upon completion of their course work. A minimum of 6 credits each must be taken in an area of history other than the candidate's specialty and in a cognate field or archival option. For M.Ed. candidates, the cognate field must be in a field of professional education. Master's candidates who write a thesis must take a minimum of 12 credits of course work at the 500 level and 6 credits of research at the 600 level. With the consent of their adviser, master's candidates may substitute 6 credits of 500-level course work in history and a paper for the 6 credits of 600-level work and thesis. M.A. candidates in all areas except U.S. and British history shall offer at the time of admission at least one academic year's work in foreign language appropriate to their area or demonstrate proficiency in such language by the beginning of their second year in the program.

Doctoral Degree Requirements
Ordinarily, doctoral programs are limited to American, Ancient, Modern European, Russian and Soviet, East Asian, and Latin American history. Prospective doctoral candidates should inquire of the head of the department about the current availability of any of these or other areas before beginning work on a doctoral degree. Doctoral candidates must pass oral and written examinations in one of the above areas of history, in a field of specialization within that area, in a field in a second area of history, and in a cognate field consisting of 15 credits of work in a single discipline other than history or

in two or more disciplines other than history where the course work is related to the subject of the candidate's research interest. Doctoral candidates must have, or acquire, a reading knowledge of two foreign languages or one foreign language and competence in quantitative techniques where appropriate to research to be done for the degree. A foreign language is not required for the D.Ed. degree, but the candidate must complete a minor in education. Three credits in historiography (HIST 502 or its equivalent) are required of all doctoral candidates.

Other Relevant Information

The department's graduate officer, who supervises the overall graduate program in History and maintains student records, will assign newly admitted graduate students to advisers on the basis of each student's expressed area of interest. Advisers provide career counseling, assistance in planning courses of study, guidance in choosing thesis and dissertation topics, and direction in conducting research. Students who serve as graduate assistants will be given a variety of experiences as they assist different professors, ranging from paper-grading and administering exams, to preparing and delivering occasional lectures, to conducting quiz sections for large lecture courses, to having, on occasion, complete responsibility for instruction in a section of a course.

Student Aid

In addition to the fellowships, graduate assistantships, and other forms of financial aid described in the STUDENT AID section of the *Graduate Bulletin,* the following awards typically have been available to graduate students in this program:

James Hamilton Hartzell and Lucretia Irvine Boyd Hartzell History Award — A $200-$300 award made annually to a graduate student in history whose field of interest is Pennsylvania history.

Hill Fellowships for Study in History —Awarded periodically by the history department to doctoral candidates who are working on their dissertations. Amount of award varies.

Edwin Erle Sparks Dissertation Fellowship in the Humanities — Available to a doctoral candidate in one of the following graduate programs: classics, comparative literature, English, French, German, history, linguistics, philosophy, religious studies, Slavic languages and literatures, Spanish, and speech communication; stipend $8,040 plus tuition. Apply to department before February 1.

Edwin Erle Sparks Fellowships in the Humanities (8) — Available to beginning graduate students in one of the following graduate programs: classics, comparative literature, English, French, German, history, linguistics, philosophy, religious studies, Slavic languages and literatures, Spanish, and speech communication; stipend $6,740 plus tuition. Apply to department before February 1.

HISTORY (HIST)

402. The Rise of the Greek Polis (3) *Borza*
403. Alexander the Great and the Hellenistic World (3) *Borza*
404. Rome and Hellenism (3) *Harvey*
405. The Roman Empire (3) *Harvey*
407. Early Medieval Society (3) *Sweeney*
408. Church and State in the High Middle Ages (3) *Sweeney*
412. Intellectual History of the Middle Ages (3) *Sweeney*
414. Renaissance and Reformation (3) *Spielvogel*
417. The Age of Absolutism (3) *Linker*
418. The French Revolution and the Napoleonic Era (3) Cross
420. Recent European History (3) *Silverman*
422. Modernity and Its Critics: European Thought Since 1870 (3) *Knight*
423. Economic History of Europe Since 1750 (3) *Silverman*
425. Work and Leisure in Industrial Europe (3) *Cross*
427. Germany Since 1860 (3) *Silverman*
430. Eastern Europe in Modern Times (3) *Enteen*
432. History of Russia to 1700 (3)
433. Imperial Russia, 1700-1917 (3) *Enteen*
434. History of the Soviet Union (3) *Enteen*
436. Great Britain Under the Tudors and Stuarts, 1485-1688 (3) *Linker*

437. Great Britain, 1688-Present (3)
440. Colonial America to 1753 (3) *Frantz*
441. Revolutionary America, 1753-1783 (3) *Frantz*
442. The Early American Republic, 1783-1850 (3) *Ginzberg*
444. The United States in Civil War and Reconstruction — 1850-1877 (3) *Gallagher*
445. The Emergence of Modern America (3) *Eggert*
446. America Between the Wars (3)
447. Recent American History (3)
449. Constitutional History of the United States to 1877 (3) *Stebbins*
450. Constitutional History of the United States Since 1877 (3) *Stebbins*
452. History of U.S. Foreign Relations (3) *Maddox*
454. American Military History (3) *Gallagher*
458. (L S 458) History of American Organized Labor Since 1877 (3) *Eggert*
459. Social and Cultural History of the United States Since 1783 (3) *McMurry*
460. United States Foreign Intelligence (3) *Ameringer*
467. Latin America and the United States (3) *Ameringer*
468. Mexico and the Caribbean Nations in the Twentieth Century (3) *Ameringer*
471. History of Arabic Civilization, 600-1258 (3) *Goldschmidt*
472. The Ottoman Empire and Other Muslim States (3) *Goldschmidt*
473. The Contemporary Middle East (3) *Goldschmidt*
479. History of Imperialism and Nationalism in Africa (3)
483. Chinese Society and Culture to 1800 (3) *Sun*
485. Nineteenth-Century China (3) *Sun*
486. Twentieth-Century China (3) *Duiker*
488. Twentieth-Century Southeast Asia (3) *Duiker*
490. (L ST 490) Archival Management (1-3)
495. Internship (1-18)
496. Independent Studies (1-18)
497. Special Topics (1-9)
499. Foreign Study — History (1-6)

501. Historical Method (3) *Staff*

502. Historiography (3) *Borza and Enteen*

503. Studies in Greek History (3-6) *Borza*

504. Studies in Roman History (3-6) *Harvey*

509. Medieval Civilization (3-9) *Sweeney*

515. Early Modern Europe (3-6) A graduate seminar examining selected topics in early modern European history through readings, discussions, and research papers.

517. Studies in Modern European Social History (3-6) A graduate seminar examining the literature and methodologies of European social history since 1750 through readings, discussions, and research papers.

520. Studies in Twentieth-Century Europe (3-6) *Silverman*

522. Studies in Modern European Intellectual History (3-6) A seminar examining developments in modern European intellectual history through readings, class discussions, and research papers.

533. Studies in Russian and Soviet History (3-6) *Enteen*

537. Studies in British History (3-6) *Linker*

540. Studies in Colonial and Revolutionary America (3-6) *Frantz*

543. The United States, 1783-1877 (3-6)

545. The United States, 1877 to Present (3-6) *Eggert*

550. Studies in Constitutional History (3-9) A graduate seminar examining constitutional developments in their historical context through readings, class discussions, and research papers. *Stebbins*

553. Diplomatic History of the United States (3-6) *Maddox*

559. Cultural History of the United States (3-6) *Brown*

569. Seminar in Latin-American History (3-6) *Ameringer*

573. Studies in Middle Eastern History (3-6) *Goldschmidt*

583. Studies in Asian History (3-9) *Sun and Duiker*

591. Archives Practicum (3-6) Training and supervised work experience in archival activities — Option A: Archival Management; Option B: Oral History. Prerequisite: HIST (L ST) 490.

595. Internship (1-12) Supervised off-campus, nongroup instruction, including field experiences, practicums, or internships. Written and oral critique of activity required. Prerequisite: prior written approval of proposed assignment by instructor.

596. Individual Studies (1-9)

597. Special Topics (1-9)

602. Supervised Experience in College Teaching (1-3 per semester, maximum of 6)

HOME ECONOMICS EDUCATION (HE ED)

SUSAN F. WEIS, *In Charge of Graduate Programs in Home Economics Education*
212 Rackley Building
814-863-3858

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Senior Member of the Graduate Faculty
Susan F. Weis, Ph.D. (Penn State) *Associate Professor of Home Economics Education*

Research and graduate courses may be chosen to give emphasis to special areas of interest in Home Economics Education, such as curriculum development; evaluation; teaching at the elementary, secondary, adult, or higher education levels; supervision; administration in colleges; or research.

Admission Requirements

Scores from the Graduate Record Examination (GRE), or from a comparable substitute examination accepted by a graduate program and authorized by the dean of the Graduate School, are required for admission. At the discretion of a graduate program, a student may be admitted provisionally for graduate study in a program without these scores. Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin*.

Students who have majored as undergraduates in some aspect of home economics and who have achieved a junior-senior grade-point average of at least 2.50 will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests. Students who want to be admitted to the doctoral programs must have completed a master's degree and will be admitted subject to limitations of program resources. New admissions are accepted any semester.

There is no foreign language requirement for degrees in the program.

Student Aid

Graduate assistantships available to students in this program and other forms of student aid are described in the STUDENT AID section of the *Graduate Bulletin*.

HOME ECONOMICS EDUCATION (HE ED)

406. Audio-Visual Methods for Home Economics (1-4)
427. Teaching Home Economics (3)
463. Pre-Student-Teaching Seminar (1)
464. Post-Student-Teaching Seminar (1)
477. Curriculum Development for Home Economics in Secondary Schools (3)

478. Appraising Student Progress in Home Economics (3)
481. Employment Preparation Programs in Vocational Home Economics (3)
482. Postsecondary, Adult, and Continuing Education Programs in Home Economics (3)
495. Student Teaching (6-9)
496. Independent Studies (1-18)
497. Special Topics (1-9)

502. Home Economics Instruction at the College Level (3) Teaching techniques suitable for college instruction in home economics; for prospective home economics college teachers.

503. Home Economics Teacher Education (3) Organization of college programs of teacher education; use of resources; records; field services; recruitment and selection of personnel. Prerequisite: two years' experience in teaching home economics.

504. Educational Issues and Home Economics (3) Contemporary issues in education and their relationship to the teaching of home economics. Prerequisite: teaching experience.

510. Educational Leadership in Home Economics (2-6) Principles of educational leadership for home economists preparing for administration; supervision of city and state programs; supervision of student teachers. Prerequisites: graduation from a four-year teacher education major and two years' teaching experience in home economics.

518. Evaluation of Home Economics Programs (3) Methods of evaluating progress toward goals in home economics education and use of findings in program planning and revision.

521. Home Economics Education Seminar (1-3) Selected topics and recent developments in home economics education. Conferences and guidance relative to individual research problems.

577. Curricula in Home Economics (3) Development of curricula in home economics. Prerequisite: HE ED 477.

595. Internship in Home Economics Supervision and Administration (2-8) Opportunity to understudy an educational leader in student teacher supervision, department or college administration, or regional consultation. Prerequisite: HE ED 510.

596. Individual Studies (1-9)

597. Special Topics (1-9)

602. Supervised Experience in College Teaching (1-3 per semester, maximum of 6)

HORTICULTURE (HORT)

FRANCIS H. WITHAM, *Head of the Department*
103 Tyson Building
814-865-2571

Degrees Conferred: Ph.D., M.S., M.Agr.

Senior Members of the Graduate Faculty
Richard N. Arteca, Ph.D. (Washington State) *Associate Professor of Horticultural Physiology*
Charles D. Boyer, Ph.D. (Penn State) *Professor of Plant Breeding and Genetics*
Richard Craig, Ph.D. (Penn State) *Professor of Plant Breeding*
Kathleen B. Evensen, Ph.D. (Florida) *Assistant Professor of Postharvest Physiology*
Paul Grun, Ph.D. (Cornell) *Professor of Cytology and Cytogenetics*
Carl W. Haeseler, Ph.D. (Penn State) *Professor of Pomology*
Charles W. Heuser, Ph.D. (Rutgers) *Associate Professor of Horticultural Physiology*
E. Jay Holcomb, Ph.D. (Penn State) *Associate Professor of Floriculture*
Jack C. Shannon, Ph.D. (Illinois) *Professor of Horticultural Physiology*
Cyril B. Smith, Ph.D. (Penn State) *Professor of Plant Nutrition*
Richard F. Stinson, Ph.D. (Ohio State) *Professor of Agricultural Education and Horticulture*
Loren D. Tukey, Ph.D. (Ohio State) *Professor of Pomology*
John W. White, Ph.D. (Penn State) *Professor of Floriculture*
Francis H. Witham, Ph.D. (Indiana U) *Professor of Horticultural and Plant Physiology*

Associate Members of the Graduate Faculty
David J. Beattie, Ph.D. (Michigan State) *Assistant Professor of Ornamental Horticulture*
Richard H. Cole, Ph.D. (Penn State) *Associate Professor of Crop Science*
Robert M. Crassweller, Ph.D. (Ohio State) *Assistant Professor of Tree Fruit*
Roland R. Daniels, Ph.D. (Wisconsin) *Associate Professor of Horticulture*
George C. Elliott, Ph.D. (North Carolina State) *Assistant Professor of Floriculture*
George M. Greene II, Ph.D. (Penn State) *Associate Professor of Pomology*
Larry J. Kuhns, Ph.D. (Ohio State) *Associate Professor of Ornamental Horticulture*
Michael D. Orzolek, Ph.D. (Maryland) *Associate Professor of Vegetable Crops*
Dennis J. Wolnick, Ph.D. (Penn State) *Associate Professor of Floriculture Extension*

Students may specialize in several phases of production, plant genetics and breeding, soils and plant nutrition, horticultural physiology, postharvest physiology, plant propagation, and agricultural meteorology. Students who want additional credits in the commodity areas of floriculture, olericulture, ornamental horticulture, and pomology, or in the areas of specialization listed above, should register for HORT 596.

Admission Requirements
Scores from the Graduate Record Examination (GRE), or from a comparable substitute examination accepted by a graduate program and authorized by the dean of the Graduate School, are required for admission. At the discretion of the graduate program officer, a student may be admitted provisionally for graduate study in a program without these scores. Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin.*

Prerequisites for admission vary according to the area of specialization, but basic courses in physical sciences, mathematics, biological sciences, communication skills, and social sciences and humanities are required. Students who lack prerequisite courses may be admitted but are required to make up deficiencies without degree credit.

Students with a 2.75 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students.

Master's Degree Requirements
All M.Agr. candidates must present one seminar (HORT 590) and an acceptable paper on a selected professional problem, or a report of internship training. Up to 3 graduate credits will be given for an acceptable paper. The candidate may be required to provide one or more copies of the paper for the University. All M.S. degree candidates must take or must have taken at least one graduate course in biometry and must present two seminars (HORT 590). A thesis is required for the M.S. degree.

Doctoral Degree Requirements
The communication requirement for the Ph.D. degree may be satisfied by completing at least 6 graduate credits in an area of communications skills approved by the student's advisory committee.

All Ph.D. candidates must present at least three seminars (HORT 590) for credit. Attendance at seminars is expected of all graduate students. All Ph.D. candidates must have completed at least two graduate courses in statistics or statistical applications (AGRO 512 and 545 or their equivalents).

An oral candidacy examination must be taken within six months after beginning residency.

Within one semester after passing the candidacy examination, the student's doctoral committee, with the thesis adviser in charge, will have the program planning meeting. The purposes of this meeting are to (1) determine the student's strengths and weaknesses in pertinent subject matter areas; (2) guide the student in developing a plan of study; and (3) review and discuss the proposed thesis research.

The comprehensive examination, composed of both written and oral parts, will be given when, in the student's and adviser's opinion, the student is ready for the examination, and when the communication requirements and essentially all courses have been completed.

After the thesis is completed and all other requirements for the Ph.D. have been met, the dean of the Graduate School will schedule the final examination. Normally, three months must elapse between the comprehensive and the final examinations. A major part of the examination will be an oral defense of the thesis.

Student Aid
In addition to the fellowships, traineeships, graduate assistantships, and other forms of financial aid described in the STUDENT AID section of the *Graduate Bulletin,* the following award typically has been available to graduate students in this program:

Walter Thomas Memorial Scholarship — Available to students studying the nutrition of horticultural crops; stipend equivalent to a half-time assistantship. Apply through the Department of Horticulture.

HORTICULTURE (HORT)

402. Plant Nutrition (2-3) *Bergman*
407. Plant Breeding (3) *Boyer*
410. Integrated Crop Management I: Theory (3)
411. Integrated Crop Management II: Applications (3)
412W. Post-Harvest Physiology (3) *Evensen*
420. Chemical Growth Regulators for Horticultural Crop Production (3) *Arteca*
421. Plant Tissue Culture (3) *Witham and Heuser*
430. Landscape Maintenance and Management (3)
431. Small Fruit Culture (3) *Daniels*
432. Deciduous Tree Fruits (3) *Daniels*
433. Vegetable Crops (3) *Grenoble*
434. Nursery Crop Production (3) *Beattie*
444. Advanced Plant Breeding (4) *Craig*
453. Flower Crop Production and Management (3) *Holcomb*
455. Retail Horticulture Business Management (3) *Holcomb*
464. Landscape Construction I (4)
466. Landscape Construction II (5)
468. Landscape Estimating and Bidding (2)
495. Internship (1-13)
496. Independent Studies (1-18)
497. Special Topics (1-9)

501. Reproductive Physiology of Cultivated Plants (3) Anatomical and physiological processes involved in sexual and asexual reproduction, including pollination, seed development, germination, rooting, grafting, and tissue culture.

503. Agricultural Production Systems (3) Analyses of soil, plant, and atmospheric components in agricultural production. *Russo*

504. Physics and Management of the Greenhouse Environment (3) Evaluation of plant growth and development in an enclosed environment from both physiological and structural perspectives.

506. Nutrition of Horticultural Crops (2-4) Principles, applications, and interpretations of diagnostic methods for determining fertilizer requirements of horticultural crops. *Smith*

507. Physiological Genetics and Plant Breeding (3) Inheritance and breeding of plants for biochemical and physiological characteristics. *Boyer*

512. Advanced Topics in Postharvest Physiology (3) Physiological processes associated with flower senescence, leaf senescence, and fruit ripening. Prerequisites: HORT 412W, BIOL 441. *Evensen*

520. Isolation and Characterization of Plant Growth Substances (2) Procedures for the isolation and characterization of known endogenous plant growth substances. Prerequisites: HORT 420, BIOL 441. *Arteca*

524. Experimental Procedures in Plant Science Research (3) Experimental methods, computer techniques, interpretation of statistical analyses, and communication of research results. Prerequisite: AGRO 512 or 3 credits in 400-level statistics. *Craig*

590. Colloquium (1-3)

596. Individual Studies (1-9)

597. Special Topics (1-9)

602. Supervised Experience in College Teaching (1-3 per semester, maximum of 6)

HUMAN DEVELOPMENT AND FAMILY STUDIES (HD FS)

JOHN R. NESSELROADE, *Acting Department Head, Individual and Family Studies*
S-105 Henderson Building
814-863-0241

LYNNE FEAGANS, *In Charge of Graduate Programs in Human Development and Family Studies*
S-105 Henderson Building
814-863-0241

Degrees Conferred: Ph.D., M.S., M.Ed.

Senior Members of the Graduate Faculty
Jay Belsky, Ph.D. (Cornell) *Professor of Human Development*
Ann C. Crouter, Ph.D. (Cornell) *Associate Professor of Human Development*
Judith Dunn, Ph.D. (Cambridge) *Professor of Human Development*
Paul A. Games, Ph.D. (Iowa) *Professor of Human Development*
Jacqueline V. Lerner, Ph.D. (Penn State) *Assistant Professor of Human Development*
Gerald E. McClearn, Ph.D. (Wisconsin) *Evan Pugh Professor of Health and Human Development*
Susan M. McHale, Ph.D. (North Carolina) *Associate Professor of Human Development*
John R. Nesselroade, Ph.D. (Illinois) *Research Professor of Human Development*
Robert Plomin, Ph.D. (Texas) *Professor of Human Development*
K. Warner Schaie, Ph.D. (Washington) *Evan Pugh Professor of Human Development and Psychology*
Michael A. Smyer, Ph.D. (Duke) *Professor of Human Development*
Alexander von Eye, Ph.D. (Trier) *Professor of Human Development*
Steven H. Zarit, Ph.D. (Chicago) *Professor of Human Development*

Associate Members of the Graduate Faculty
Elizabeth J. Crockett, Ph.D. (Chicago) *Assistant Professor of Human Development*
David J. Eggebeen, Ph.D. (North Carolina) *Assistant Professor of Human Development*
David Estes, Ph.D. (Michigan) *Assistant Professor of Human Development*
Michael E. Lamb, Ph.D. (Yale) *Adjunct Professor of Human Development*
Nancy L. Pedersen, Ph.D. (Colorado) *Adjunct Assistant Professor of Human Development*
Richard A. Pierce, Ph.D. (Texas) *Assistant Professor of Individual and Family Studies*
Michael Rovine, Ph.D. (Penn State) *Assistant Professor of Human Development*
Cynthia A. Stifter, Ph.D. (Maryland) *Assistant Professor of Human Development*
Stephen J. Suomi, Ph.D. (Wisconsin) *Adjunct Professor of Human Development*

This interdisciplinary program is one of the graduate programs of the College of Health and Human Development. It is administered through the Department of Individual and Family Studies. Human Development and Family Studies focuses on the developmental study of individuals, small groups, and families for the purposes of expanding basic knowledge and professional application. The perspective encompasses the individual life span, from infancy and childhood through later maturity and old age, as well as the full cycle of the family. For both individual and family, the perspective includes variations in functioning patterns and the use of resources; the impact of diverse social, economic, and cultural contexts upon behavior; conditions that promote adaptive individual, group, and family development; and the creation of techniques of accomplishing human development. Emphasis is upon the integration of knowledge from various fields for understanding and developing skills for careers in research and scholarship, teaching, program planning and evaluation, and other professional services. The faculty includes persons primarily in the behavioral and social sciences particularly committed to research and application in these multi- and interdisciplinary areas.

The student's program is expected to include work assuring both breadth in the major field and depth within one of three program areas: family development, human development intervention, or individual development. Further specialization is possible in adult development and aging, biological bases of behavior, child and adolescent development, cognitive development and functioning, early childhood services, family economics and management, family relationships, integrative theories of human development, interpersonal relationships, methods for studying change, and social-emotional development and change.

The Child Development/Child Services Laboratory is operated as part of the teaching and research program. Each of three units has observational facilities and rooms for study of individual and group behavior of children and adults. The Individual and Family Consultation Center provides facilities for the development and evaluation of educational programs for remediation of individual and family

problems by professional and paraprofessional persons. The Institute for the Study of Human Development and the Gerontology Center provide opportunities for participation in research and evaluation projects. Additional resources are available in other parts of the University.

Admission Requirements

Scores from the Graduate Record Examination (GRE) are required for admission. Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin.*

Entering students should have at least 6 credits in the biological and physical sciences; 12 in the social sciences and, depending upon proposed area of emphasis, basic courses in sociology, psychology, and economics; and 6 in developmental and family studies. Students not meeting these requirements may be admitted with limited deficiencies to be made up concurrently with their graduate work.

Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission for fall semester only. Early application is required, and a special application to HD FS must be completed; additional information can be obtained from the professor in charge. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

Degree Requirements

All students must take a two-semester introduction to the fundamental philosophical, theoretical, methodological, and professional issues in the study of human development. In addition, master's students must take a 6-credit research and evaluation methodology core, and Ph.D. students must take an 18-credit research and evaluation methodology core. Twelve of these credits are courses taken by all Ph.D. students. The other 6 credits may be satisfied by selections from a variety of courses. Use may be made also of courses in other parts of the college and University to build substantive competence in the program. The communication and foreign language requirement for the Ph.D. degree may be satisfied by options selected from designated areas including, but not restricted to, foreign languages.

Candidates for the M.Ed. degree must take 6 credits in a field of professional education.

Student Aid

Graduate assistantships available to students in this program and other forms of student aid are described in the STUDENT AID section of the Graduate Bulletin.

INDIVIDUAL AND FAMILY STUDIES (I F S)

410. Communities and Families (3)
411. The Helping Relationship (3)
412. Adult-Child Relationships (3)
413. Developmental Problems in Adulthood (3)
414. Resolving Individual and Family Problems (3)
415. Program Development in Family Relationships (3)
418. Family Relationships (3)
420. Laboratory in Individual and Family Enhancement (3)
424. Family Development in an Economic Context (3)
428. Infant Development (3)
429. Advanced Child Development (3)
430. Practicum in Preschool Groups (1-10)
432. Developmental Problems in Childhood and Adolescence (3)
435. Developmental Transition to Adulthood (3)
442. Home Management Experience (3)
445. (PSY 445) Development Throughout Adulthood (3)
450. Developmental Child Programs and Services (3)
453. Family Participation and Involvement in Child Services (3)
454. (C & S 454) Development and Administration of Child Service Programs (3)
468. Biological Bases of Behavioral Development (3)
470. (PSY 470) Social Learning Foundations of Behavior Change (3)
477. Analysis of Family Problems (2-9)

490. Introduction to Field Experience (1)
491. Design of Field Research Projects (2)
495. Advanced Field Experience (1-12)
496. Independent Studies (1-18)
497. Special Topics (1-9)

500. Nonthesis Research (1-9)

501. Seminar: Issues in the Study of Individual and Family Development (1-3) Reading, reports, and discussion of conceptual frameworks for multidisciplinary and developmental study of individuals and families.

504. Practicum in Program Development for Preschool Children (2-6) Investigation, analysis, and report on the design, development, and evaluation of a selected program for preschool children. Prerequisites: 6 credits of individual development and I F S 430, 453.

506. Projects in Design and Evaluation of Programs for Preschool Children (2-4) Individual projects in the design, implementation, and evaluation of different teaching approaches with varying groups of children. Prerequisites: I F S 504 and 3 credits in research methods.

508. Parental Education (1-6) Implementing educational and preventive programs for parents; discussion and evaluation of theory and techniques.

511. Modifying Conjugal Life (1-9) Conceptual foundations, research procedures, and practicum experience in teaching effective communication and problem-solving skills in the marriage relationship. Prerequisites: 6 credits in individual development or psychology and 3 credits in statistics.

512. Filial Relationship Modification (1-9) Theory, research, and practicum in teaching parents to resolve developmental problems in their own children. Prerequisites: 6 credits in individual development or psychology and 3 credits in statistics.

513. Group Procedures in Individual Development (1-6) Theory, research, and practicum experience in the use of group methods for promoting individual development in different age groups. Prerequisites: I F S 411 and research methods or statistics.

515. Teaching Individual Development and Family Studies (1-6) Objectives, techniques, materials, and evaluation in teaching at the secondary and college level, and in adult and public education programs.

519. Methods of Statistical Analysis in Human Development (3) An overview of basic statistical concepts, models, and methods for the analysis of development and change. Prerequisites: H DEV 516, introductory statistics.

520. Seminar in Prenatal and Infant Development (1-6) Prenatal and infant development, with emphasis on multiple determinants of early development and their relationship to later behavior. Prerequisites: 6 graduate credits in individual development, psychology, or biological science and 3 credits in statistics.

522. Seminar in Dysfunction Processes in Individual Development (1-6) Multiple processes involved in dysfunctional development in the individual across the life span. Prerequisite: I F S 413.

524. Theoretical Analysis of Family Economic and Managerial Behavior (3) Conceptual approaches and major contributions to the study of the organizational, managerial, and economic functions of the family. Prerequisite: I F S 418 or 424 or 477.

525. Theories of Family Relationships (3) Assessment of the utility of major theories for empirical analysis of interpersonal interactions among family members. Prerequisite: I F S 418.

526. (PSY 526) Measurement in Human Development (3) Principles and methods for assessment of human developmental processes across the life span. Prerequisites: EDPSY 450 or PSY 450; H DEV 516, I F S 519.

529. (PSY 529) Seminar in Child Development (1-6) Readings and reports on recent findings in child development. Prerequisites: 6 graduate credits in child development, child psychology, or educational psychology, plus 3 credits in statistics.

536. (PSY 536) Research Methods in Developmental Processes (3) Methodological issues in research on varying stages of development across the individual life span. Prerequisites: 6 credits in individual development or psychology and a course in statistics.

539. Seminar in Adolescent Development (1-6) Cultural, psychological, and biological aspects of the developmental transition to adulthood. Prerequisites: 6 credits in individual development or psychology and 3 credits in sociology and statistics.

543. Modification of Family Managerial Practices (1-3) Conceptual issues, research, and practicum experience in assisting families in the solution of financial and managerial problems.

544. Seminar in Dysfunctional Patterns in Family Organization (1-6) Processes of familial dysfunction and disorganization and their explanation in economic, social-psychological, and managerial terms. Prerequisite: I F S 418 or 424 or SOC 430.

545. Families and Socioeconomic Systems (1-6) Functional interrelationships between families and social and economic systems. Prerequisites: I F S 418, 424.

546. Seminar in Family Relationships (1-9) Interpersonal interaction within family systems throughout the life cycle. Prerequisite: I F S 418.

549. (PSY 549) Developmental Theory (3) Conceptual frameworks and major contributions to the study of individual development across the life span. Prerequisites: 6 credits at the 400 level in individual development or psychology.

550. Seminar in Family Economics and Management (1-6) Recent developments in the study of family economic and managerial practices.

579. Seminar in Adult Development and Aging (1-9) A seminar dealing with specific topics concerning adult development and aging. Prerequisites: I F S (PSY) 445, statistics.

590. Colloquium (1-3)

595. Field Projects in Individual and Family Studies (1-9) Supervised research or internship in human services program. Prerequisite: instructor's approval of proposed project.

596. Individual Studies (1-9)

597. Special Topics (1-9)

HUMANITIES (HUMAN)

LOUISE E. HOFFMAN, *Coordinator, Humanities*
Penn State Harrisburg, The Capital College
Middletown, PA 17057
717-948-6189

Degree Conferred: M.A.

Senior Members of the Graduate Faculty
Mihailo Dordevic, Docteur es Lettres (Paris) *Professor Emeritus of Humanities and Literature*
Francis Ferguson, Ph.D. (Columbia) *Professor of Humanities and Architecture*
Robert J. Graham, Ph.D. (Pennsylvania) *Associate Professor of Humanities and American Studies*
Theodora R. Graham, Ph.D. (Pennsylvania) *Associate Professor of Humanities and English*
Irwin Richman, Ph.D. (Pennsylvania) *Professor of American Studies and History*
George D. Wolf, Ph.D. (Pennsylvania) *Professor Emeritus of American Studies and History*
Melvin H. Wolf, Ph.D. (Michigan) *Professor of Humanities and English*

Associate Members of the Graduate Faculty
Michael L. Barton, Ph.D. (Pennsylvania) *Associate Professor of Social Science and American Studies*
Simon J. Bronner, Ph.D. (Indiana) *Associate Professor of Folklore and American Studies*
Eton F. Churchill, M.F.A. (Tulane) *Assistant Professor of Humanities and Multimedia Journalism*
Garry Hagberg, Ph.D. (Oregon) *Assistant Professor of Humanities and Philosophy*
Louise E. Hoffman, Ph.D. (Bryn Mawr) *Assistant Professor of Humanities and History*
William J. Mahar, Ph.D. (Syracuse) *Associate Professor of Humanities and Music*
John S. Patterson, Ph.D. (Brown) *Associate Professor of American Studies and History*
Lynne Retford, Ph.D. (Oregon) *Assistant Professor of Humanities and Romance Languages*
Troy M. Thomas, Ph.D. (California) *Assistant Professor of Humanities and Art*
Donald Wolff, Ph.D. (Washington) *Assistant Professor of Humanities and Writing*

The Master of Arts program in Humanities, offered at Penn State Harrisburg, is designed to help the student develop skills for investigating and interpreting relationships among the various arts. It provides the basis for highly individualized study of arts and ideas. It includes courses in art, history, literature, music, and philosophy, but unlike traditional single-discipline programs, its emphasis is interdisciplinary. The program is designed to accommodate the needs of part-time students.

Admission Requirements

Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin.*

Entering students are expected to have studied in two of the major humanities disciplines, usually having a major in one and some course work in another. Exceptions may be made for those with special backgrounds or abilities who are committed to advanced study in two areas. An admissions committee interviews all applicants, in person or by telephone. Students with a 2.50 junior-senior average and with applicable undergraduate backgrounds will be considered for admission. Applicants are required to submit evidence of their writing ability. Students applying for fellowships or assistantships must submit scores from the Graduate Record Examination (GRE).

Degree Requirements

To qualify for the M.A. in Humanities, the student must demonstrate competence in applying methods of humanistic inquiry to relevant subject areas. A supervisory committee, selected by the student, works closely with the student to determine individual needs and guides the selection of courses, independent studies, and final production. A series of seven 500-level courses, three of which are required, is designed to assist students in developing both disciplinary and interdisciplinary skills. Independent studies and appropriate 400-level courses offer additional training in specific areas. For students planning to teach in a junior or community college, a teaching internship is available.

The student must complete a minimum of 30 credits, at least 18 of which must be at the 500 level. However, the degree is not simply a recognition of credits compiled; it testifies that the student has cultivated the necessary skills of analysis and synthesis and has successfully completed a master's production.

A full-time student can expect to complete the program in three semesters, a part-time student in six semesters. Students are expected to complete all requirements for the degree in six years, although the deadline may be extended at the discretion of the graduate coordinator.

HUMANITIES (HUM)

REQUIRED COURSES

500. Research Methods and Scholarly Inquiry in the Humanities (3) Study of the methods and materials of scholarship, use of reference tools, evaluation of evidence, and writing of research papers.

560. Interrelations in the Humanities (3) The study and practice of conducting interdisciplinary research and of investigating and supporting inter-art analogies. Prerequisite: HUM 500.

580. Master's Production (1-6) An original scholarly master's paper or creative production initiated by the student, supervised by an appropriate professor, and judged by a committee.

RECOMMENDED COURSES

515. Seminar (3 per semester, maximum of 9) A seminar focusing on typical methods and approaches of a single discipline within the humanities. (May be repeated for credit.)

Unit A. Art History (3) Study of sources and documents, style analysis, iconography, criticism, interpretation, and social context of art, within a selected chronological period.

Unit B. History (3) Study of a particular historical period or theme, emphasizing critical use of sources, interpretive approaches, and theories.

Unit C. Literature (3) Study of a period, form, author, or idea and/or investigation of a fundamental problem in literary aesthetics or theory.

Unit D. Music History and Analysis (3) Study of a period, style, composer, or genre and/or investigation of problems in the aesthetics or history of music.

Unit E. Philosophy (3) Detailed investigation of a period of philosophy, e.g., ancient, contemporary, or of a fundamental problem, e.g., mind, language, ethics, logic.

525. Studies in Aesthetics (3) Philosophical investigation into the nature of art, aesthetic experience, artistic meaning, criticism, grounds for judgment, and history of aesthetic theory.

530. Seminar in Comparative Arts (3) A seminar focusing on selected periods, styles, genres, or artists in two or more areas within the humanities.

535. Topics in Cultural and Intellectual History (3) Study of methods, issues, and selected topics in the history of thought, social values, and creative expression.

OTHER RELEVANT 500-LEVEL COURSES

590. Colloquium (1-3)

596. Individual Studies (1-9)

597. Special Topics (1-9)

Additional courses may be taken from the following list and at the 400- or 500-level in related fields with the concurrence of the student's adviser.

AMSTD 452. The American Renaissance (3)

AMSTD 459. America's Coming of Age 1914-1939 (3)

AMSTD 460. American Art and Architecture of the Seventeenth and Eighteenth Centuries (3)

AMSTD 463. American Music (3)

AMSTD 480. Museums and Culture (3)

C ART 415. Studio Art (3)

C ART 420. Critical Approaches to Art (3)

C ART 427. Masters of Art (3)

C ART 428. Renaissance Art (3)

C ART 429. Baroque Art (3)

C ART 430. Nineteenth-Century Art in Europe (3)

C ART 431. Modern Art (3)

C ART 440. Topics in Art (3)

ENLSH 405. Advanced Writing (3)

HUM 405. Periods in Intellectual and Cultural History (3)

HUM 409. Myth and Children's Literature (3)

HUM 410. Religion and Culture (3)

HUM 430. Philosophy and Literature (3)

HUM 441. Myth, Symbol, and Ritual (3)

HUM 453. Literature and Society (3)

HUM 460. Thematic Studies (3)

HUM 461. Selected Periods in the Humanities (3)

LIT 427. Masters of Literature (3)

LIT 440. Form and Function (3)

LIT 450. Cultural Patterns in Literature (3)

LIT 460. Literary Periods (3)

LIT 461. Studies in Literary Style (3)

C MUS 427. Masters of Music (3)

C MUS 440. Forms in Music (3)

C MUS 460. Studies in Musical Style (3)

M-M 430. Writer's Seminar (3)

M-M 452. Film and Cultural Values (3)

M-M 461. Advanced Reporting (3)

M-M 480. Studies in Media (3)

M-M 483. Television Production (5)

PHLOS 415. Aesthetics (3)

PHLOS 431. Philosophical Perspectives (3)

PHLOS 447. Philosophical Periods (3)

PHLOS 490. Philosophical Topics (3)

THTRE 406. Studies in Theatre (3)

INDUSTRIAL ENGINEERING (I E)

ALLEN L. SOYSTER, *Head of the Department of Industrial and Management Systems Engineering*
207 Hammond Building
814-865-7601

Degrees Conferred: Ph.D., M.S., M.Eng.

Senior Members of the Graduate Faculty
Tom M. Cavalier, Ph.D. (Virginia Polytechnic) *Assistant Professor of Industrial Engineering*
M. Jeya Chandra, Ph.D. (Syracuse) *Associate Professor of Industrial Engineering*
Paul H. Cohen, Ph.D. (Ohio State) *Associate Professor of Industrial Engineering*
Ernest E. Enscore, Jr., Ph.D. (Penn State), P.E. *Professor of Industrial Engineering*
Andris Freivalds, Ph.D. (Michigan) *Associate Professor of Industrial Engineering*
Inyong Ham, Ph.D. (Wisconsin) *Professor of Industrial Engineering*
Kenneth Knott, Ph.D. (Loughborough), P.E. *Associate Professor of Industrial Engineering*
Deborah J. Medeiros, Ph.D. (Purdue) *Associate Professor of Industrial Engineering*
Claude D. Pegden, Ph.D. (Purdue) *Associate Professor of Industrial Engineering*
Matthew Rosenshine, Ph.D. (SUNY) *Professor of Industrial Engineering*
Allen L. Soyster, Ph.D. (Carnegie-Mellon) *Professor of Industrial Engineering*
Richard A. Wysk, Ph.D. (Purdue) *Professor of Industrial Engineering*

Associate Members of the Graduate Faculty
John W. Davis, Ph.D. (Penn State) *Associate Professor of Industrial Engineering*
Pius J. Egbelu, Ph.D. (Virginia Polytechnic) *Assistant Professor of Industrial Engineering*
Joseph H. Goldberg, Ph.D. (Michigan) *Assistant Professor of Industrial Engineering*
Catherine M. Haronosky, Ph.D. (Purdue) *Assistant Professor of Industrial Engineering*
Sanjay Joshi, Ph.D. (Purdue) *Assistant Professor of Industrial Engineering*
Eugene Kozik, Ph.D. (Pittsburgh) *Associate Professor of Industrial Engineering*
Amine Lehtihet, Ph.D. (Lehigh) *Assistant Professor of Industrial Engineering*
Brian J. Melloy, Ph.D. (South Florida) *Assistant Professor of Industrial Engineering*

Graduate study and research are conducted in operations research–management science, production engineering, process design, systems engineering, human factors, ergonomics, and robotics.

Admission Requirements
Scores from the Graduate Record Examination (GRE), or from a comparable substitute examination accepted by a graduate program and authorized by the dean of the Graduate School, are required for admission. At the discretion of a graduate program, a student may be admitted provisionally for graduate study in a program without these scores. Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin*.

To be admitted into the program, an applicant must have received a baccalaureate degree from an accredited institution. Graduates in engineering, physical sciences, and mathematics who present a 2.50 grade-point average will be considered for admission. For all international students whose na-

tive language is not English, scores from the Test of English as a Foreign Language (TOEFL) are required with a minimum score of 550 required for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

Degree Requirements

Three degrees are offered: the Master of Engineering (M.Eng.), the Master of Science (M.S.), and the Doctor of Philosophy (Ph.D.). For the M.Eng. degree, 27 credits of course work beyond the baccalaureate level are required, of which at least 12 credits must be at the 500 level and 15 credits must be in industrial engineering courses. In addition, a paper, for which 3 credits of I E 596 may be used, is required of all candidates for the M.Eng. degree. For the M.S. degree, 24 credits of course work are required, of which at least 12 credits must be at the 500 level, and 12 credits must be in industrial engineering courses. In addition, a thesis, for which 6 credits may be used, also is required. For the Ph.D. degree, 21 credits of 500-level industrial engineering courses beyond the baccalaureate level and 6 technical credits from other departments are required.

Continuous registration is required for all graduate students until the thesis is approved.

Other Relevant Information

Students in this program may elect the dual-title degree program option in Operations Research for the Ph.D. and M.S. degrees (see p. 299).

The M.Eng. degree is also offered at Penn State Great Valley.

Student Aid

In addition to the fellowships, traineeships, graduate assistantships, and other forms of financial aid described in the STUDENT AID section of the *Graduate Bulletin,* the following awards typically have been available to graduate students in this program:

W. S. Elliott Fellowship — Available to a graduate student who is a graduate of Penn State and is interested in engineering research; stipend variable. Apply to Office of the Dean, College of Engineering, 101 Hammond Building.

Tau Beta Pi Fellowship — Open to any member of Tau Beta Pi, the engineering honor society, for a year of advanced study. Up to eighteen awards of $3,500 each are available. Applications and information can be obtained from the Office of the Dean, College of Engineering, 101 Hammond Building. Application deadline is February 15.

Benjamin W. Niebel Manufacturing Fellowship — Consideration for this fellowship shall be given to all students exhibiting academic excellence who have been admitted to Penn State as candidates for a graduate degree in the Department of Industrial and Management Systems Engineering, College of Engineering.

INDUSTRIAL ENGINEERING (I E)

400. Engineering for Production (3)
401. Work Measurement Applications (3)
403. Engineering Economy and Statistics (3)
404. Management Science (3)
405. Linear Programming (3)
407. Quantitative Methods in Industrial Engineering III (3)
408. Human Factors Engineering (3)
414. Materials Joining Processes and Principles (3)
419. Safety Systems Engineering (3)
423. Quality Control and Reliability (3)
425. Introduction to Operations Research (3)
426. Industrial Automation (3)
427. Solidification of Castings (3)
428. Foundry Engineering (3)
430. Industrial Project (3)
432. Introduction to Reliability Engineering (1-3)
438. Metal Cutting Principles and Practice (3)
439. Engineering Systems Optimization (3)
450. Manufacturing Systems Engineering (3)
451. Numerical Control (3)

452. Microcomputers — Programming and Industrial Applications (3)
453. Simulation Modeling of Industrial Systems (3)
454. Applied Decision Analysis (3)
456. (M E 456) Industrial Robot Applications (3)
461. Welding Inspection and Quality Control (3)
463. Computer Graphics in Industrial Engineering (3)
494. Senior Thesis (1-9)
496. Independent Studies (1-18)
497. Special Topics (1-9)

501. Manufacturing Methods (2-8) Special projects including investigation, experimentation, design, and research of one or more special types of manufacture. Prerequisite: I E 400.

505. Linear Programming (3) An accelerated treatment of the main theorems of linear programming and duality structures plus introduction to numerical and computational aspects of solving large-scale problems. Prerequisite: I E 405.

506. Work Design and Measurement (3-9) Methods of research in motion and time study; critical analysis of current literature. Prerequisite: I E 401.

507. Operations Research: Scheduling Models (3) Scheduling models with simultaneous job arrival and probabilistic job arrival, network scheduling, and scheduling simulation techniques. Prerequisite: I E 425.

508. Operations Research: Inventory Models (3) A study of inventory theory, deterministic models, probabilistic models, multiproduct models in both the single and multiperiod modes. Prerequisite: I E 425.

509. Operations Research: Waiting Line Models (3) Waiting line models including models with infinite queues, finite queues, single and multiple servers under various priorities and disciplines. Prerequisite: I E 425.

510. Mathematical Programming (3) Study of advanced topics in linear programming including duality, decomposition, sensitivity analysis, parametric programming, and selected topics in mathematical programming. Prerequisite: I E 405.

511. Experimental Design in Engineering (3) Statistical design and analysis of experiments in engineering; experimental models and experimental designs using the analysis of variance. Prerequisite: I E 323.

512. Graph Theory and Networks in Management Science (3) Prerequisite: I E 425.

513. Real-Time Microcomputer Applications (3) Study of real-time industrial engineering microcomputer applications, including the hardware and software techniques necessary to implement these systems. Prerequisite: I E 452.

514. Data Management Systems Design (3) Computer-based technology and design requirements for data acquisition and entry, data communications, transaction management, data-base management, and data utilization. Prerequisite: I E 513.

515. Complex Linear Flow Models (3) Application of complex linear flow models in engineering and management science, including static and dynamic system simulations. Prerequisite: I E 405.

516. Applied Stochastic Processes I (3) Prerequisite: STAT (MATH) 416.

518. Plastic Deformation Processes (3) Study of the principles, theories, technology, design, and application of plastic deformation processes to shape metals. Prerequisites: I E 214, METAL 259.

519. Dynamic Programming (3) Study of the concepts underlying model-building and optimization of dynamic systems with application to engineering, economic, and environmental systems. Prerequisite: I E 516.

520. Goal Programming (3) Study of concepts and methods in analysis of systems involving multiple objectives with applications to engineering, economic, and environmental systems. Prerequisite: I E 405 or Q B A 451.

521. Engineering Systems Optimization (3) Fundamental theory of optimization, including classical optimization, search methods, functional optimization; with engineering applications as industrial, mechanical, and chemical processes. Prerequisite: FORTRAN programming ability.

522. Industrial Systems Simulation (3) Study of discrete-event, network, and continuous simulation of industrial and manufacturing systems using the SLAM/GASP-IV languages; statistical techniques in simulation methodology. Prerequisites: I E 322 and FORTRAN programming ability.

528. Metal Cutting Theory (3) Study of the theory of metal cutting, contemporary and future problems of metal removal processes; critical analysis of current literature. Prerequisite: I E 438.

532. Reliability Engineering (3) Mathematical definition of concepts in reliability engineering; methods of system reliability calculation; reliability modeling, estimation, and acceptance testing procedures. Prerequisite: I E 323 or 3 credits in probability and statistics with a prerequisite of calculus.

538. Experimental Investigations in Materials Processing (3) Experimental investigation on selected subjects in processing involving instrumentation, methods, and analysis. Prerequisite: I E 528.

550. Manufacturing Systems (3) Fundamental theory for analyzing manufacturing systems including structural analysis, optimization and economics of manufacturing systems, automated and computer-aided manufacturing. Prerequisite: I E 450.

551. Computer Control of Manufacturing Systems (3) Analysis of microprocessor-controlled servo loops, adaptive control, stochastic methods in control; analysis of NC machines, robots, and their controllers. Prerequisites: I E 451.

552. (BIOE 552, E MCH 552) Mechanics of the Musculoskeletal System (3) Structure and biomechanics of bone, cartilage, and skeletal muscle; dynamics and control of musculoskeletal system models. Prerequisite: consent of program. Prerequisite or concurrent: BIOL 472.

553. (BIOE 553) Engineering of Human Work (3) Physics and physiology of humans at work; models of muscle strength; dynamic movements; neural control; physical work capacity; rest allocation. Prerequisite: BIOL 041 or 472.

554. Production, Planning, and Control (3) Analysis of research literature for topics, including scheduling, capacity planning, and lot sizing applied to manufacturing and production. Prerequisite: I E 507.

555. Performance Evaluation of Queueing (3) Study of the methodologies available to obtain the equilibrium results of open and closed queueing networks with single and multiple classes of customers. Prerequisite: I E 509.

556. (M E 556) Robotic Concepts (3) Analysis of robotic systems; end effectors, vision systems, sensors, stability and control, off-line programming, simulation of robotic systems. Prerequisite: I E 456 or M E 456.

558. Engineering of Cognitive Work (3) Information-processing and decision-making models of the human in the modern workplace, emphasizing visual inspection and other industrial applications. Prerequisites: I E 323, 408.

561. Weld Design (3) Weld design examining joint configuration, loading conditions, weld size, to avoid brittle fracture and fatigue failure in weldments. Prerequisite: I E 414.

562. Expert Systems Design in Industrial Engineering (3) Methodological aspects of expert systems design and review of some existing systems with emphasis on manufacturing and industrial engineering. Prerequisites: I E 450; background in one programming language would be useful.

563. Computer-Aided Design for Manufacturing (3) Study of CAD systems and concepts, including 3D wireframe and solid modeling systems, emphasizing manufacturing applications. Prerequisite: I E 463.

564. Welding Physics and Chemistry (3) In-depth study of welding arc physics, metal transfer modes and flow, welding automation and control, and the weldability of materials. Prerequisite: I E 414 or 461.

565. Manufacturing Facilities Design (3) Study of the factors that influence the selection and design of facilities for manufacturing. Prerequisites: I E 327, 425.

566. Quality Control (3) Advanced quality assurance and control topics, including multivariate methods, economic design for control and acceptance, dimensioning, tolerancing, and error analysis. Prerequisite: I E 423.

596. Individual Studies (1-9)

597. Special Topics (1-9)

LABORATORY ANIMAL MEDICINE (L A M)

C. MAX LANG, *Chair of the Department of Comparative Medicine*
The Milton S. Hershey Medical Center
Hershey, PA 17033
717-531-8460

Degree Conferred: M.S.

Senior Member of the Graduate Faculty
C. Max Lang, D.V.M. (Illinois) *George T. Harrell, Jr., Professor of Comparative Medicine*

Associate Members of the Graduate Faculty
Teresa A. Bowman, D.V.M. (Washington) *Assistant Professor of Comparative Medicine*
Peggy J. Danneman, V.M.D. (Pennsylvania) *Assistant Professor of Comparative Medicine*
James W. Griffith, D.V.M. (Missouri) *Associate Professor of Comparative Medicine*

The department offers a postdoctoral program for veterinarians leading to the Master of Science degree with a major in Laboratory Animal Medicine. Laboratory animal medicine is a specialty of veterinary medicine that is concerned with the biology of laboratory animals and their comparative relationships to humans. Postdoctoral training in this discipline provides a broad, basic foundation upon which the individual can build a career in teaching and research in laboratory animal medicine and/or in the professional direction of research animal facilities. The program has a strong research-oriented base with emphasis on comparative medicine and pathology.

This program is offered only at The Milton S. Hershey Medical Center.

Admission Requirements

With the approval of the dean of the Graduate School, the faculty of the graduate program in Laboratory Animal Medicine does *not* require Graduate Record Examination scores or scores from any substitute examination for admission to the program. Students with a 3.00 junior-senior average, with a doctor of veterinary medicine degree, and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

Degree Requirements

The program requires two years for completion. Basically, the first year consists of formal course work, while the second year is devoted mainly to research and the development of clinical skills and techniques. A student must have earned a minimum of 12 credits in a major subject, 6 credits in a minor subject, and 6 credits of thesis research in order to receive the graduate degree. Approved minors have been established in anatomy, behavioral science, biological chemistry, microbiology, pathology, pharmacology, and physiology.

Student Aid

In addition to the fellowships, traineeships, graduate assistantships, and other forms of financial aid described in the STUDENT AID section of the *Graduate Bulletin,* the following award typically has been available to graduate students in this program:

U.S. Public Health Service Traineeships in Laboratory Animal Medicine — Available to selected graduate students in laboratory animal medicine who are planning research-oriented careers; stipend varies. Apply to the graduate program in Laboratory Animal Medicine (Hershey).

COMPARATIVE MEDICINE (C MED)

501. Biology and Care of Laboratory Animals (3) Presentation of the anatomic and physiologic characteristics of the commonly used laboratory animal species and their relation to biomedical research.

503. Laboratory Animal Genetics (3) Genetic principles applied to laboratory animals used for investigations of diseases that may be controlled or influenced by genetic factors.

505. Laboratory Animal Zoonoses (2) Experimentally induced, spontaneous, and infectious diseases transmissible between man and animals, with special emphasis on etiology, differential diagnosis, and control.

507. Techniques of Laboratory Animal Experimentation (3) Techniques of drug administration, infusion, and collection of body fluids and materials; gnotobiology; use of radioisotopes and bioinstrumentation.

510. Animal Physiological Surgery (3) Selected operative procedures, demonstrating principles of physiology with modern biomedical instrumentation, will be followed through the postoperative period.

515. Experimental Surgery of Laboratory Animals (3) Surgical techniques, including nephrectomy and Goldblatt clamp, bladder and gastric pouches, bile duct cannulation, intraventricular operation, cardiac and cerebrovascular catheterization.

530. Diseases of Laboratory Animals I (3) Physiological and pathological expressions of both infectious and metabolic-degenerative diseases of rodents, with emphasis on diagnostic and control methods.

531. Diseases of Laboratory Animals II (3) Physiological and pathological expressions of both infectious and metabolic-degenerative diseases of nonhuman primates and other species of animals.

535. Comparative Pathology (3) Comparative pathologic characteristics of infectious and metabolic diseases of animals and man.

590. Colloquium (1-3)

596. Individual Studies (1-9)

597. Special Topics (1-9)

LANDSCAPE ARCHITECTURE (LARCH)

NEIL H. PORTERFIELD, *Head*
210 Engineering Unit D
814-865-9511

Degree Conferred: M.L.A.

Associate Members of the Graduate Faculty
A. Mark Battaglia, M.L.A. (Harvard) *Associate Professor of Landscape Architecture*
Daniel R. Jones, M.L.A. (Harvard) *Associate Professor of Landscape Architecture*
E. Lynn Miller, M.L.A. (Harvard) *Professor of Landscape Architecture*
Neil H. Porterfield, M.L.A. (Pennsylvania) *Professor of Landscape Architecture*
David L. Young, M.L.A. (Harvard) *Professor of Landscape Architecture*

Admission Requirements
Scores from the Graduate Record Examination (GRE), or from a comparable substitute examination accepted by a graduate program and authorized by the dean of the Graduate School, are required for admission. At the discretion of the program, a student may be admitted provisionally for graduate study without these scores. Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin*.

Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

All applicants must submit a minimum of two recommendations from faculty acquainted with the applicant's academic history; a paper of not more than five hundred words on landscape architecture stating the applicant's understanding of graduate education and describing his or her professional interests and goals; and evidence of creativity.

Applicants with degrees in landscape architecture, architecture, or other design or visual arts fields must submit a portfolio of their work. Applicants with a nonart background must provide evidence of creative and analytical problem-solving abilities. Applicants with nonart or nondesign backgrounds probably will have to remove deficiencies in graphics communications skills and design problem solving. Applicants with an art or design background probably will have to remove deficiencies in the sciences and engineering. It is expected that all applicants, except those with undergraduate degrees in landscape architecture, will be deficient in design theory and physical design problem solving as applied to landscape architecture. Qualifying applicants will be interviewed by the Landscape Architecture Graduate Program Selection Committee.

Degree Requirements

The core curriculum is a two-year, 46-credit program intended for students with an undergraduate degree in landscape architecture. All other students will be required to remove deficiencies. It is anticipated that students entering with an undergraduate degree in a closely related field (e.g., architecture) will require one additional year to remove deficiencies. Students entering from unrelated fields (e.g., philosophy, art history, agriculture) will require more than one year to remove deficiencies.

Students will be required to take studio courses at the 500 level (12 credits), a concentration area (9 credits), electives (15 credits), and to prepare a thesis or professional or research project (10 credits).

Student Aid

Graduate assistantships available to students in this program and other forms of student aid are described in the STUDENT AID section of the *Graduate Bulletin*.

LANDSCAPE ARCHITECTURE (LARCH)

425. Intermediate Landscape Design (4)
427. Intermediate Landscape Planning (4)
435. Landscape Construction I (4)
437. Landscape Construction II (5)
444. Landscape Architecture Field Trip (1)
445. Advanced Landscape Planning (5)
447. Advanced Landscape Design (5)
457. Professional Practice (1)
458. Advanced Landscape Communications (2)
471. Park Planning Theory and Concepts (2)
472. Planning and Public Policy (3)
474. Site Engineering Fundamentals (1)
475. Park Systems Practicum (1)
495. Internship (1-13)
496. Independent Studies (1-18)
497. Special Topics (1-9)

518. Advanced Problems in Landscape Design (2-12) Selected problems for original investigation in the design, construction, and maintenance of landscape architectural projects.

520. Problems in Landscape Architecture (2-12) Problems in landscape architectural planning and design, including programming and application of various design scales.

521. Technical Landscape Architectural Practices (2-12) Specific technical and professional problems in landscape architectural planning and practice.

590. Colloquium (1-3)

594. Research Topics (1-15) Supervised student activities on research projects identified on an individual or small group basis.

595. Internship (1-15) Supervised off-campus, nongroup instruction, including field experiences, practicums, or internships. Written and oral critique of activity required.

596. Individual Studies (1-9)

597. Special Topics (1-9)

LINGUISTICS (LING)

PHILIP H. BALDI, *In Charge of Graduate Programs in Linguistics*
425 Moore Building
814-865-6873

Degree Conferred: M.A.

Senior Members of the Graduate Faculty
Philip H. Baldi, Ph.D. (Rochester) *Professor of Linguistics and Classics*
John B. Dalbor, Ph.D. (Michigan) *Professor of Spanish*
Ernst A. Ebbinghaus, Ph.D. (Marburg) *Professor of German and Comparative Literature*
Keith E. Nelson, Ph.D. (Yale) *Professor of Psychology*
David S. Palermo, Ph.D. (Iowa) *Professor of Psychology*
William R. Schmalstieg, Ph.D. (Pennsylvania) *Professor of Slavic Languages and Linguistics*
Ellen Woolford, Ph.D. (Duke) *Assistant Professor of Linguistics and Anthropology*

Associate Members of the Graduate Faculty
Ronald E. Buckalew, Ph.D. (Illinois) *Associate Professor of English*
Davida H. Charney, Ph.D. (Carnegie-Mellon) *Assistant Professor of English*
Patricia A. Dunkel, Ph.D. (Arizona) *Assistant Professor of Speech Communication*
Joyce Neu, Ph.D. (USC) *Assistant Professor of Speech Communication*
Philip M. Prinz, D.Ed. (Boston) *Associate Professor of Communication Disorders*
Deborah M. Rekart, Ph.D. (Louisiana State) *Assistant Professor of Speech Communication*
Avigail Vicente, Doctorate de 3^{e} Cycle (Paris) *Assistant Professor of French*

The Linguistics program offers two options for graduate study, one in general linguistics and one in applied linguistics. The general M.A. degree program includes courses in historical linguistics, phonology and syntax, psycholinguistics, experimental phonetics, semantics, and sociolinguistics. In the applied option, the candidate pursues general courses in syntax, semantics, and phonology, then chooses, with the help of the graduate adviser, a coherent set of electives in a specialized area that may be a language or a related field, such as teaching English as a second language, psycholinguistics, communication disorders, or French linguistics. The program requirements allow for considerable flexibility in the choice of electives for students pursuing either the general or applied option. An acceptable thesis or paper must be submitted and a set of written comprehensive examinations passed.

Admission Requirements
Scores from the Graduate Record Examination (GRE) verbal, quantitative, and analytical tests are required for admission to the M.A. program. In unusual circumstances, a student may be admitted *provisionally* on the basis of grades, letters of recommendation, and other admission criteria, but *all* students must have taken the GRE exams before the end of their first semester of study. Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin*.

The minimum requirement for admission to an advanced program will normally be a B.A. degree in linguistics or an equivalent in any of the interdisciplinary subjects recognized as a specialized area. Students with deficiencies will be required to register for a course in grammatical analysis and a course in phonetics/phonology.

Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

Degree Requirements
The M.A. in Linguistics requires 36 credits in either a general or an applied option. The general M.A. student must take two exams in a core theoretical area (syntax, semantics, phonology) and one exam in a third area (sociolinguistics, historical, psycholinguistics, or the third core area). Students in

the applied M.A. must take one exam in applied linguistics, one in a core area, and one in a third area to be determined by the student's program (e.g., English as a Second Language, Communication Disorders, etc.).

In addition to completing the three exams successfully, each student must complete an original research paper done under the direction of a program faculty member. These papers are typically revised and expanded versions of outstanding term papers written for regular courses and must conform to acceptable standards of linguistic scholarship. Papers are judged by two faculty members. A copy of the final version must be submitted to the department. The M.A. student is expected to demonstrate reading proficiency in one foreign language.

Student Aid

In addition to the fellowships, traineeships, graduate assistantships, and other forms of financial aid described in the STUDENT AID section of the *Graduate Bulletin,* the following awards typically have been available to graduate students in this program:

Edwin Erle Sparks Fellowships in the Humanities (8) — Available to beginning graduate students in one of the following graduate programs: classics, comparative literature, English, French, German, history, linguistics, philosophy, religious studies, Slavic languages and literatures, Spanish, and speech communication; stipend $6,740 plus tuition. Apply to department before February 1.

LINGUISTICS (LING)

400. Syntactic Theory I (3)
401. Introduction to Linguistic Theory (3)
403. Phonological Analysis (3)
404. Generative Phonology (3)
413. (SPCOM 413) Experimental Linguistics (3)
415. Contrastive Analysis (3)
420. (PSY 420) Advanced Psycholinguistics (3)
448. Introduction to Sociolinguistics (3)
449. Introduction to Semantics (3)
482. (SPCOM 482) Introduction to Applied Linguistics (3)
493. Informant Work (3)
496. Independent Studies (1-18)
497. Special Topics (1-9)

500. Syntactic Theory II (3) Further development of the generative-transformational model; the analysis of higher-order grammatical structures. Prerequisite: LING 400.

502. Historical Linguistics (3) Principles of comparative linguistics; language families; reconstruction of phonemic, morphemic, and syntactic structure of extinct languages. Prerequisite: LING 400.

503. Generative Syntax (3) Grammatical rules specifying well-formed strings; conditions on analyzability and assigning of structural descriptions; deviation from well-formedness. Prerequisite: LING 500.

504. Generative Phonology (3) Distinctive feature theory in the generative framework; articulatory and acoustic correlates; nonphonemic features. Prerequisite: LING 500.

505. Seminar in Historical Linguistics (3) Detailed study of some problem of historical linguistics, e.g., the laryngeal theory, Indo-European ablaut, etc. Prerequisite: one course in historical linguistics.

517. (CMDIS 517) Theoretical Bases of Language Disorders in Children and Adults (3) Application of linguistic theory to the understanding of communication disorders, with clinical implications for speech and language therapy. Prerequisites: 12 credits in communication disorders or related fields, including a course in language acquisition.

520. (PSY 520) Seminar in Psycholinguistics (3 per semester, maximum of 9) Consideration of theoretical and research issues relevant to psychological aspects of language sounds, syntax and semantics, and other cognitive support.

551. (SPCOM 551) Linguistic Analysis of a Non-Indo-European Language (3) An investigation into the phonological, morphological, syntactic, and discourse structures of a selected non-Indo-European language. Prerequisites: LING 400 or 403 or SPCOM 484.

570. Foundations of Linguistic Theory (3) A critical survey of generative-transformational grammar from 1957 to the present.

590. Seminar in Interdisciplinary Linguistics (3-12) Methods of research. Common and individual investigations in interdisciplinary fields of linguistics in consultation with one or more interdisciplinary instructors. Prerequisite: LING 500.

596. Individual Studies (1-9)

597. Special Topics (1-9)

602. Supervised Experience in College Teaching (1-3 per semester, maximum of 6)

MANAGEMENT

JOHN J. MULHERN, *in-charge*
Penn State Great Valley

Degree Conferred: M.Mgmt.

The aim of this intercollege program is to enable the student interested in management in the public, private, or nonprofit sector to pursue an integrated program of study covering the fundamentals of management, the interfaces of the several sectors with one another, and a choice of specializations applicable to one or more of these sectors.

Programs are arranged through a selection of appropriate courses offered by several departments in the Colleges of Business Administration, Health and Human Development, and the Liberal Arts.

Areas of specialization include public administration, business administration, contract management, and health care administration. In addition, a technology management specialization is under development. Required research in any of these areas of specialization may be conducted in Penn State Great Valley's Library and Computer Center, which provide local research support as well as access to the other library and computer resources of the Penn State system.

The M.Mgmt. program is designed to accommodate the needs of part-time students who are generally employed full-time. Courses in the management program, which are offered at the Graduate Center and at other Penn State campuses and corporate training centers, are scheduled for the convenience of adult learners, usually in the evening and on Saturday.

The program is overseen by a five-member intercollege committee on management. The committee is composed of members of the Business Administration, Health and Human Development, and Public Administration graduate faculties at the University Park Campus and Penn State Great Valley, who teach in the program. Members are appointed to the committee by the dean of the Graduate School. The dean of the Graduate School will designate a committee chair, who will serve as program chair and will be responsible for attesting to completion of degree requirements.

Admission Requirements

Scores from the Graduate Record Examination (GRE), Graduate Management Admission Test (GMAT), or Law School Admission Test (LSAT) are required for admission. At the discretion of the committee, a student may be admitted provisionally to the program without these scores. Requirements listed below are in addition to the Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin*.

Entering students should hold a bachelor's degree from an accredited institution in a business, health, liberal arts, or closely related field. Students should have had at least one year of quantitative analysis. Students with a 3.00 junior-senior grade-point average (GPA) and with appropriate course backgrounds will be considered for admission. Exceptions to the minimum GPA may be made for students with special backgrounds, abilities, and interests.

Degree Requirements

All degree candidates take a required core program of 15 credits covering the theoretical, methodological, and technological components of management. An additional 15 credits are taken in an indi-

vidualized faculty-approved program in general management or in one of the four specialization options. Each option includes both required courses and electives. With approval of the committee, a student in one option may select elective courses from other options.

All students complete a final written research project that may be either a 3-credit professional research paper based on term papers written in courses or a 6-credit essay written on a new topic.

Each final written research project is overseen by an advisory committee made up of two members of the graduate faculty. Ordinarily, one member of the committee will be drawn from Penn State Great Valley, and the other, the University Park Campus. Students will be given the opportunity to invite faculty members to serve on their committees. Advisory committee assignments will be approved by the chair of the committee on management.

Student Aid

Graduate assistantships available to students in this program and other forms of student aid are described in the STUDENT AID section of the *Graduate Bulletin*. Additional information is available from the director of student services at Penn State Great Valley.

MAN-ENVIRONMENT RELATIONS (M E R)

STUART H. MANN, *Professor-in-Charge*
96 Henderson Building
814-863-4849

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Senior Members of the Graduate Faculty

Peter B. Everett, Ph.D. (North Carolina) *Associate Professor of Marketing*
Stuart H. Mann, Ph.D. (Case Western Reserve) *Professor of Operations Research*
Arthur H. Patterson, Ph.D. (Northwestern) *Associate Professor of Environment and Behavior*
Richard R. Ritti, Ph.D. (Cornell) *Professor of Organizational Behavior*

Associate Members of the Graduate Faculty

Sidney Cohn, Ph.D. (North Carolina) *Professor of Urban Design*
Fred J. DeMicco, Ph.D. (Virginia Polytechnic) *Assistant Professor of Hotel, Restaurant, and Institutional Management*
H. A. Divine, Ph.D. (Washington) *Professor of Hotel, Restaurant, and Institutional Management*
Robert M. Griffin, Jr., Ph.D. (North Carolina) *Associate Professor of Environmental Planning*
Carolyn Lambert, Ph.D. (Tennessee) *Associate Professor of Food Service Administration*
Sara J. Parks, R.D., M.B.A. (Michigan State) *Associate Professor of Dietetics*

Graduate studies emphasizing Hotel, Restaurant, and Institutional Management (HR&IM) are designed to prepare individuals for executive, research, or educational roles in the hospitality industry and can be pursued through this program.

The program in Man-Environment Relations with an emphasis in environment-behavior studies educates students in such issues by (1) developing an understanding of the interactions between environmental forces and human behavior, and by (2) learning to apply facts, principles, and theories from behavioral and social science to solve problems of the environmental designer, planner, and manager. Specifically, it aims to train students to undertake problem-focused research in both academic and applied settings and to translate the results of such research into terms useful to the creation of effective and satisfying environments for living and working.

For those students emphasizing environment-behavior studies and entering without a master's degree, an M.S. degree is awarded, but it is not considered a terminal degree or professional degree. Students enrolling in the program are expected to work for the Ph.D. degree. Students in the program may elect the dual-title degree program in Operations Research for the Ph.D. and M.S. degrees (see p. 326).

Admission Requirements

Scores from the Graduate Record Examination (GRE), or from a comparable substitute examination accepted by a graduate program and authorized by the dean of the Graduate School, are required for admission. At the discretion of a graduate program, a student may be admitted provisionally for graduate study in a program without these scores. Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin*.

Students with a 3.00 junior-senior grade-point average will be considered for admission. Exceptions to this minimum average are sometimes made for students with special backgrounds, abilities, interests, and circumstances. Appropriate undergraduate preparation may be in the design and planning professions, environmental and urban studies, as well as other physical, social, or behavioral science programs relevant to the study of man-environment systems.

Master's Degree Requirements

A master's thesis is required of all students. The thesis is to be based on original empirical research. A master's committee of three persons who oversee the master's thesis is appointed for each candidate. This committee gives the final master's exam, which is an oral defense of the master's thesis.

Each environment-behavior studies student must complete a core of three courses (M E R 506, 507, and 508). These courses provide an overview of various environment-behavior research perspectives and their application to specified problems, as well as an introduction to research design and data collection methods, problem-solving methods for planning and policy development in environment-behavior systems, design of laboratory research and field-research methods, and the use of mathematical models.

Doctoral Degree Requirements

Beyond the same core of three courses required for the master's degree and in addition to satisfying the requirements of the Graduate School, prior to being allowed to schedule the Ph.D. comprehensive examination, a student must show satisfactory evidence of proficiency in statistics. This evidence can be provided by obtaining a grade of B or better in one of a number of 500-level statistics courses at the University.

The language or communication requirement for the Ph.D. can be fulfilled by (1) demonstrating proficiency in an approved foreign language, or (2) demonstrating proficiency in computer programming, or (3) completing a minor. The demonstration of proficiency is determined by an M E R faculty committee.

Student Aid

Graduate assistantships available to students in this program and other forms of student aid are described in the STUDENT AID section of the *Graduate Bulletin*.

HOTEL, RESTAURANT, AND INSTITUTIONAL MANAGEMENT (HR&IM)

402. Equipment, Layout, and Design of Hospitality Operations (3)
405. Legal Aspects of Hospitality Service Industry (3)
410. Advanced Quantity Food Production (2-5)
411. Beverage Management and Wine Selection (3)
415. Gastronomy for Restaurants (3)
435. Financial Management in Hospitality Operations (3)
436. Hospitality Operational Management (3)
442. Marketing for the Hospitality Industries (3
443. Sales Planning and Advertising for Hospitality Operations (3)
465. Organizational Behavior in the Hospitality Industry (3)
466. Personnel Functions in the Hospitality Industry (3)
467. Management of Hotel and Restaurant Employee Relations (3)
470. Hospitality Management Information Systems (3)
490. Hospitality Operations Planning (3)
493. Hospitality Management Seminar (1-6)
495. Hotel Internship (3)
496. Independent Studies (1-18)
497. Special Topics (1-9)

MAN-ENVIRONMENT RELATIONS (M E R)

500. Nonthesis Research (1-6)

501. Problems in Man-Environment Relations (1-9) Individual directed study, investigation, and practice in selected aspects of man-environment relations.

502. Seminar in Man-Environment Relations (1-9)

503. Research Methods and Evaluation in Man-Environment Relations (1-9)

505. Environmental-Behavioral Programming, Design, and Management (3) Applications of findings in the behavioral sciences to environmental design and management strategies; empirical, theoretical, and methodological issues.

506. Theory and Applications in Environment-Behavior Relations (4) An overview of the field of man-environment relations with emphasis on current research perspectives and their application to real-world problems.

507. Field Research Methods in Man-Environment Relations (4) A survey of methods, problems of research design, and data collection in field research in man-environment relations.

508. Problem-Solving Methods in Man-Environment Relations (4) Study of problem-solving methods for planning and policy development in environment-behavior systems, with laboratory and field applications.

510. Psychological Foundations of the Study of Environment-Behavior Relations (3) Seminar relating the psychology of perception, cognition, motivation, personality, attitude formation, and psychological stress to aspects of the physical environment.

515. Environmental Systems Theory (3) An in-depth review of those elements of general systems theory relevant to the analysis and organization of man-environment settings.

516. Quantitative Methods in Environmental Management (3) The use of operations research and systems analysis in the modeling of man-environment systems. Prerequisite: M E R 515.

534. (STAT 534) Dynamic Programming (3) The study of the concepts underlying model-building and optimization of dynamic systems; applications to engineering, economic, and environmental systems. Prerequisites: STAT (MATH) 414; I E 405 or Q B A 451.

597. Special Topics (1-9)

602. Supervised Experience in College Teaching (1-3 per semester, maximum of 6)

MASS COMMUNICATIONS (MCOMM)

BRIAN WINSTON, *In Charge of the Graduate Program in Mass Communications*
201 Carnegie Building
814-865-6597

Degrees Conferred: Intercollege Ph.D., M.A.

Senior Members of the Graduate Faculty
Richard L. Barton, Ph.D. (Oregon) *Associate Professor of Communications*
John S. Nichols, Ph.D. (Minnesota) *Associate Professor of Communications*
Vincent P. Norris, Ph.D. (Illinois) *Professor of Communications*
Donald L. Smith, M.S. (Illinois) *Associate Professor of Journalism*
Brian N. Winston, M.A. (Oxford) *Dean, School of Communications, and Professor of Communications*

Associate Members of the Graduate Faculty
R. Thomas Berner, M.A. (Penn State) *Associate Professor of Journalism and American Studies*
Marlowe D. Froke, M.S. (Northwestern) *Associate Professor of Communications*
William L. Dulaney, Ph.D. (Northwestern) *Associate Dean for Undergraduate Education and Professor of Journalism*
R. Dorn Hetzel, M.A. (New York) *Associate Professor of Film and Video*
Jerome L. Holway, M.A. (Northwestern) *Assistant Professor of Film and Video*
Mary S. Mander, Ph.D. (Illinois) *Associate Professor of Communications*
Frederic A. Mortiz, M.S. (Columbia) *Associate Professor of Journalism*
Patrick R. Parsons, Ph.D. (Minnesota) *Assistant Professor of Communications*
John V. Pavlik, Ph.D. (Minnesota) *Assistant Professor of Advertising*
Roberta Pearson, Ph.D. (New York) *Assistant Professor of Communications*
Daniel W. Pfaff, Ph.D. (Minnesota) *Associate Professor of Journalism*
John N. Rippey, M.S. (Columbia) *Assistant Professor of Journalism*
Jeffrey S. Rush, M.F.A. (Iowa) *Assistant Professor of Film and Video*
William C. Uricchio, Ph.D. (New York) *Assistant Professor of Communications*

Admission Requirements
Scores from the Graduate Record Examination (GRE) are required for admission. At the discretion of the graduate committee and the director of graduate studies, a student may be admitted provisionally

for graduate study in the program without these scores with the understanding that the scores will be submitted before the end of the first semester, at which time a final decision regarding admission will be made. Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin.*

Students with a 3.00 junior-senior average are eligible for admission. Two letters of recommendation are required. Applicants must also submit an autobiographical statement of about 1,000 words indicating the nature of the applicant's interest in mass communications, reasons for wanting to do graduate work, and future aspirations relating to the general field of mass communications. Exceptions to the above may be made for students with special backgrounds, abilities, and interests.

Master's Degree Requirements

For up-to-date information about the graduate offerings in the school and their requirements, write to the Dean, School of Communications, 201 Carnegie Building, The Pennsylvania State University, University Park, PA 16802.

Doctoral Degree Requirements

The intercollege doctoral program in mass communications is administered by the Graduate School. All students seeking admission to the program are required to submit Graduate Record Examination scores, transcripts of all previous undergraduate and graduate course work, and three letters of recommendation from individuals qualified to comment on their ability to perform successfully at the doctoral level. In most cases, a completed master's degree is required for admission to the program. In addition, applicants are required to submit a formal statement indicating what they expect to achieve and how their educational background qualifies them for doctoral-level study in mass communications. Admissions decisions are made by the admissions committee of the intercollege program in mass communications.

Requirements listed above are in addition to general Graduate School requirements listed in the GENERAL INFORMATION section of the *Graduate Bulletin.*

Students admitted to the doctoral program must complete a candidacy examination. For students with a master's degree or equivalent, this examination ordinarily will occur before the student has completed 10 credits of doctoral-level work. For individuals admitted with only a baccalaureate degree and no graduate-level work, the candidacy examination will be administered after 30 credits and before 40 credits of graduate-level work have been completed. The committee designated to conduct the examination will determine whether the student's knowledge of mass communications is adequate for doctoral-level study, specify what deficiencies, if any, must be removed, and pass judgment on a proposed plan of study.

The program requirements include both semesters of the Mass Communications Proseminar (COMM [SPCOM] 501.1 and 501.2), a foundation course (SPCOM 420, COMM 413, 455, or 480), and other courses selected by the student, with committee approval, that collectively constitute a coherent sequence appropriate to the advanced study of mass communications. Students are expected to take a minimum of 20 credits in communications-related courses. No more than 6 credits can be taken as independent study credits. Students also are required to take at least one course in research methods approved by the doctoral committee. Upon completion of the course work approved for the plan of study, the candidate will take a comprehensive examination. Following the comprehensive examination, doctoral candidates must schedule a dissertation proposal meeting at which the research plan for their dissertation is reviewed and approved by their committee. Upon completion of the dissertation, doctoral candidates must present a final oral defense of their dissertation before their committee.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of one foreign language or by an equivalent research skill relevant to the student's field of study.

COMMUNICATIONS (COMM)

401. Mass Media in History (3)
403. Law of Mass Communications (3)
404. Mass Communications Research (3)
405. Political Economy of Communications (3)
407. (ECON 407) Advertising in the American Economy (3)
409. News Media Ethics (3)
410. International Mass Communications (3)
411. Cultural Aspects of the Mass Media (3)
413. The Mass Media and the Public (3)

416. (ENGL 416) Science Writing (3 per semester, maximum of 6)
417. Advertising Regulation and Ethics (3)
419. World Media Systems (3)
421. Advertising Communications Problems (3)
422. Advertising Media Planning (3)
423. Advertising Research (3)
424. Advertising Campaigns (3)
425. Advertising Message Strategy (3)
426. Current Issues in Advertising (3)
435. Broadcast News (3)
436. Public Affairs Broadcasting (3)
440. Advanced Documentary Techniques (3)
442. Advanced Film and Video Production I (3)
443. Advanced Film and Video Production II (3)
444. Advanced Film and Video Projects (1-6)
445. Advanced Directing for the Camera (3)
446. Advanced Screenwriting (3-6)
447. Advanced Electronic Image Production (3)
448. Advanced Cinematography and Sound Workshop (3)
449. Advanced Film and Video Production Practicum (1-12)
451. Topics in American Film (3)
452. Topics in International Cinema (3)
453. (C LIT 453) Narrative Theory: Film and Literature (3)
454. Documentary in Film and Television (3)
455. Advanced Film Theory and Criticism (3)
456. Film/Video and the Real World (3)
460. Reporting Methods (3)
461. Professional Journalism Seminar (3 per semester, maximum of 6)
462. The Feature Article (3)
467. News Editing and Evaluation (3)
469. Photography for the Mass Media (3)
471. Public Relations Media and Methods (3)
472. Public Relations Research Methods and Findings (3)
473. Public Relations Problems (3)
480. Theories and Issues in Mass Communications (3)
481. Television Programming and Performance (3)
482. Advanced Radio Production (3)
494. Research Topics (1-3 per semester, maximum of 12)
495. Internship (1-3)
496. Independent Studies (1-18)
497. Special Topics (1-9)
499. Foreign Study — Mass Communications (1-9)

501. (SPCOM 501) Proseminar in Mass Communications (3) Overview of paradigms in mass communications research. Prerequisite: admission to doctoral program.

504. Seminar in the History of Mass Communications (3)

505. International Communication Problems (3) Legal and communications problems of the international flow of news and opinion; international press codes.

506. Introduction to Mass Communications Research (3) The scientific method; survey of basic concepts of theoretical and empirical research; variety of methodology; criteria for adequate research.

507. News Media and Public Opinion (3) Problems in the function, techniques, and responsibilities of press, radio, and television in forming and interpreting opinion.

508. The Literature of Journalism (3)

509. Journalism Ethics (3) Evolving ethics, standards, and social responsibility in American journalism; business nature of news media; case studies.

510. Comparative Theories of Press Systems (3) Institutional structure and normative functions of press systems in modern societies, as shaped by prevailing world view and social organization.

511. Mass Communications Research Methods II (3) Problems of bibliographical research; evaluation of sources and materials in mass communications history, biography, structure, ethics, and other areas. Prerequisite: COMM 506.

512. Government and Mass Communications (3) Problems of freedom of information; governmental efforts to control mass communications agencies; government news coverage; public information agencies.

513. Constitutional Problems of the News Media (3) Problems involving conflict between guarantees of press freedom in the First and Fourteenth Amendments and rights and privileges of others.

520. Seminar in Advertising Problems (3)

540. Seminar in Directing for the Screen (3) Intensive practical exercises in directing for the screen, focusing on issues of character, narrative line, and theme.

541. Projects in Directing for the Screen (3-9) Conceptualizing, breaking-down, planning, and directing of narrative film or video. Prerequisite: COMM 540.

542. Seminar in Screenwriting (3) Intensive practical exercises in writing for the screen, focusing on issues of character and structure.

543. Projects in Screenwriting (3-9) Conception, development, and polishing of student screenplays. Prerequisite: COMM 542.

546. Production Projects (3) Conceptualizing, breaking-down, planning, and executing a production specialty.

547. Electronic Image Production (3) Film-style production approach in the video medium.

548. Cinematography and Sound (3) Intensive practical experience and studies of camerawork, lighting, and audio production. Prerequisite: COMM 442.

549. Production Practicum (1-3) Experience in production for students in theory and criticism.

550. Film Theory and Criticism (3) Studies in traditional and contemporary film theory and criticism. Prerequisite: COMM 455.

551. Film and History (3) Studies in problems of film history, historiography, and film as historical evidence. Prerequisite: COMM 455.

552. Authorship and Style (3) Studies in the analysis, evaluation, and articulation of cinematic authorship and style. Prerequisite: COMM 455.

553. Special Problems in Film and TV (1-3)

560. Reporting of State Government (3) Pennsylvania government, politics, history; emphasis on covering state agencies/departments and preparing in-depth article. Prerequisite: COMM 460 or professional newspaper experience.

580. Seminar in Telecommunications (3) Study of the historical and contemporary issues and problems in telecommunications.

590. Colloquium (1-3) Continuing seminars which consist of a series of individual lectures by faculty, students, or outside speakers.

596. Individual Studies (1-9)

597. Special Topics (1-9)

602. Supervised Experience in College Teaching (1-3 per semester, maximum of 6) Teaching or assisting in School of Communications courses by graduate students with previous news-editorial, advertising, and broadcasting experience.

MATHEMATICS (MATH)

PETER H. MASERICK, *In Charge of Graduate Programs in Mathematics*
230 McAllister Building
814-865-7527

Degrees Conferred: Ph.D., D.Ed., M.A., M.Ed.

Senior Members of the Graduate Faculty
Joel H. Anderson, Ph.D. (Indiana) *Professor of Mathematics*
George E. Andrews, Ph.D. (Pennsylvania) *Professor of Mathematics*
Steve Armentrout, Ph.D. (Texas-Austin) *Professor of Mathematics*
Paul Axt, Ph.D. (Wisconsin) *Professor of Mathematics*
Augustin Banyaga, Ph.D. (Geneva) *Associate Professor of Mathematics*
Jerry L. Bona, Ph.D. (Harvard) *Professor of Mathematics*
David M. Bressoud, Ph.D. (Temple) *Associate Professor of Mathematics*
W. Dale Brownawell, Ph.D. (Cornell) *Professor of Mathematics*
Goong Chen, Ph.D. (Wisconsin) *Associate Professor of Mathematics*
Frank R. Deutsch, Ph.D. (Brown) *Professor of Mathematics*
Edward Formanek, Ph.D. (Rice) *Professor of Mathematics*
Paul Gerardin, Ph.D. (Paris) *Professor of Mathematics*
Moses Glasner, Ph.D. (California-Los Angeles) *Associate Professor of Mathematics*
William Hager, Ph.D. (MIT) *Associate Professor of Mathematics*
Kyong T. Hahn, Ph.D. (Stanford) *Professor of Mathematics*
Richard H. Herman, Ph.D. (Maryland) *Professor of Mathematics*
Robert E. Huff, Ph.D. (North Carolina) *Associate Professor of Mathematics*
Robert P. Hunter, Ph.D. (Louisiana State) *Professor of Mathematics*
Donald G. James, Ph.D. (MIT) *Professor of Mathematics*
Thomas Jech, Ph.D. (Prague) *Professor of Mathematics*
Ram P. Kanwal, Ph.D. (Indiana) *Professor of Mathematics*
Allan M. Krall, Ph.D. (Virginia) *Professor of Mathematics*
Gerard Lallement, Doctorat es Mathematiques (Paris) *Professor of Mathematics*
W. C. Li, Ph.D. (California-Berkeley) *Associate Professor of Mathematics*
Peter Maserick, Ph.D. (Maryland) *Professor of Mathematics*
William J. Mitchell, Ph.D. (California-Berkeley) *Associate Professor of Mathematics*
Peter D. Morris, Ph.D. (Texas-Austin) *Associate Professor of Mathematics*
Gary L. Mullen, Ph.D. (Penn State) *Associate Professor of Mathematics*
John E. Olson, Ph.D. (Ohio State) *Associate Professor of Mathematics*
William G. Pritchard, Ph.D. (Cambridge) *Professor of Mathematics*
Amitai Regev, Ph.D. (Hebrew) *Professor of Mathematics*
Donald C. Rung, Ph.D. (Notre Dame) *Professor of Mathematics*
L. Ridgway Scott, Ph.D. (MIT) *Professor of Mathematics*
David A. Sibley, Ph.D. (Cal. Tech.) *Associate Professor of Mathematics*
Stephen G. Simpson, Ph.D. (MIT) *Professor of Mathematics*
Leonid N. Vaserstein, Ph.D. (Moscow State) *Professor of Mathematics*
Roger P. Ware, Ph.D. (California-Santa Barbara) *Professor of Mathematics*
William C. Waterhouse, Ph.D. (Harvard) *Professor of Mathematics*
Robert Wells, Ph.D. (Princeton) *Associate Professor of Mathematics*

Associate Members of the Graduate Faculty
Paromita Chowla, Ph.D. (Colorado) *Associate Professor of Mathematics*
Nilotpal Ghosh, Ph.D. (Cornell) *Assistant Professor of Mathematics*
Peter M. Laurence, Ph.D. (Wisconsin-Madison) *Assistant Professor of Mathematics*
L. C. Li, Ph.D. (Courant) *Assistant Professor of Mathematics*
Richard B. Mansfield, Ph.D. (Stanford) *Associate Professor of Mathematics*
Mary McCammon, Ph.D. (London) *Associate Professor of Mathematics*
Robert L. Sachs, Ph.D. (Courant) *Assistant Professor of Mathematics*
Clarence E. Wayne, Ph.D. (Harvard) *Associate Professor of Mathematics*
Zhong Yin, Ph.D. (Virginia) *Assistant Professor of Mathematics*

Graduate courses in all the principal branches of mathematics are offered regularly each year. The department is prepared to direct research in a variety of fields, including various branches of analysis, algebra, topology, number theory, applied analysis, and mathematical logic and foundations.

Admission Requirements

Scores from the Graduate Record Examination (GRE), or from a comparable substitute examination accepted by a graduate program and authorized by the dean of the Graduate School, are required for admission. At the discretion of a graduate program, a student may be admitted provisionally for graduate study in a program without these scores. Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin*.

To be admitted to the Ph.D., D.Ed., or M.A. program without undergraduate deficiency, an applicant should have completed at least 18 credits in mathematics at the advanced undergraduate level (400 series or their equivalents). The undergraduate student is urged to take at least 6 credits in foundations of analysis (MATH 401-402), 6 in modern algebra (MATH 435-436), and 3 in topology (MATH 429) or their equivalents. These courses are essential preparation for the graduate program, and if they are taken after admission, a maximum of 6 credits may be counted toward an advanced degree.

Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

Entering graduate students in mathematics for whom English is not the first language are required to have a score of at least 550 on the TOEFL (Test of English as a Foreign Language) examination. Furthermore, the results of this examination must be received by the Department of Mathematics at least six months prior to the requested date of admission to the Graduate School.

Master's Degree Requirements

For the M.A. degree the department offers two options: (1) the thesis option requires 12 credits of approved 500-series courses in mathematics, 6-9 credits of thesis, sufficient credits in approved 400- or 500-series courses to make a total of 30 credits, and a final oral examination based on the thesis and general course material; and (2) the nonthesis option requires 18 credits of 500-series courses in mathematics, sufficient credits in approved 400- or 500-series courses to make a total of 30 credits, and a term paper on an approved topic in mathematics. No final examination is given in this option. Under this option a student may also elect to take a minor in applied mathematics. In this case, he or she substitutes for 9 of the credits in mathematics 9 credits in the applied area — 6 of these credits must be at the 500 level. For both options, a grade of A or B is required in all courses.

The student also may elect to get concurrent M.A.'s in mathematics and another discipline. The program of study should satisfy the requirements for the master's degree in each department. However, 9 credits earned in cross-listed courses may count for a master's degree in both areas. The proposed program must be approved in advance by both the departments involved and by the Graduate School.

To be admitted to the M.Ed. program without undergraduate deficiency, an applicant should have completed at least 15 credits in mathematics at the intermediate level beyond calculus. The M.Ed. program does not require any 500-series courses, but the student is encouraged to select some at this level. Special courses have been instituted for the training of teachers. Among these are MATH 470, 471, and 472. These are acceptable to satisfy credit requirements only for the M.Ed. degree.

Doctoral Degree Requirements

All Ph.D. students must take qualifying examinations in two fields of mathematics. Normally, these examinations are taken before the beginning of the third year of graduate study. Recommendations for advancement to Ph.D. candidacy are based on these examinations together with performance in the first two years of study. The comprehensive examination is given after approximately 60 credits are earned and after the student has passed reading examinations in two languages chosen from French, Russian, or German. The Ph.D. student also is expected to enroll in advanced seminars.

Outstanding students who do not continue in the doctoral program may petition the department for further support in order to pursue a second master's degree in another area to which mathematics is applicable.

For the D.Ed. degree, a student must pass qualifying examinations in algebra and analysis and a reading examination in French, German, or Russian before taking the comprehensive examination. In addition to the major thesis, the department requires participation in two semesters of research seminar. The D.Ed. program is intended for college teachers. Three years of experience in professional

mathematics teaching on a full-time basis is required for admission. (Graduate teaching assistants are not included in this category.)

Other Relevant Information

Students in this program may elect the dual-title degree program option in Operations Research for the Ph.D. and M.S. degrees (see p. 299).

A brochure describing more fully the graduate program in Mathematics is available from the Department of Mathematics.

Student Aid

Graduate assistantships available through this program and other forms of student aid are described in the STUDENT AID section of the *Graduate Bulletin*.

MATHEMATICS (MATH)

401. Introduction to Analysis I (3)
402. Introduction to Analysis II (3)
403. Classical Analysis I (3)
404. Classical Analysis II (3)
405. Advanced Calculus for Engineers I: Real Variables (3)
406. Complex Analysis (3)
407. Tensor Analysis (3)
409. (STAT 409) Mathematical Statistics I (3)
410. (STAT 410) Mathematical Statistics II (3)
411. Ordinary Differential Equations (3)
412. Fourier Series and Partial Differential Equations (3)
413. Operational Mathematics (3)
414. (STAT 414) Introduction to Probability Theory (3)
415. (STAT 415) Introduction to Mathematical Statistics (4)
416. (STAT 416) Stochastic Modeling (3)
417. Qualitative Theory of Differential Equations (3)
419. (PHYS 419) Theoretical Mechanics (3)
426. Differential Geometry (3)
429. General Topology (3)
430. Elementary Algebraic Topology (3)
435. Basic Abstract Algebra (3)
436. Linear Algebra (3)
441. Matrix Algebra (3)
449. Algebraic Geometry (3)
452. Finite Differences (3)
453. (CMPSC 453) Numerical Computations (3)
454. (CMPSC 454) Matrix Computations (3)
457. Introduction to Mathematical Logic (3)
459. Computability and Unsolvability (3)
461. (PHYS 461) Theoretical Mechanics (3)
462. Introduction to Set Theory (3)
463H. Honors Research Seminar I (4)
464H. Honors Research Seminar II (4)
465. Number Theory I (3)
466. Number Theory II (3)
467. (CMPSC 467) Algorithms in Number Theory (3)
468. Mathematical Coding Theory (3)
469. Mathematics of Algorithms (3)
470. Algebra for Teachers (3)
471. Geometry for Teachers (3)
472. Probability for Teachers (3)
480. Foundations of Geometry (3)
483. Applied Modern Algebra II (3)
484. Linear Programs and Related Problems (3)
485. Graph Theory (3)
486. Mathematical Theory of Games (3)

493. Mathematics Recitation Instructor Training (1 per semester, maximum of 3)
496. Independent Studies (1-18)
497. Special Topics (1-9)

501-502. Theory of Functions of a Real Variable (3 each) Sets, metric spaces, measure and integration, Lp spaces and other function spaces, differentiation. Prerequisite: MATH 402.

503. Functional Analysis (3) Theory of Banach and Hilbert spaces, including functionals and operators, and related topics. Prerequisite: MATH 502.

505. Fundamentals of Applied Mathematics I (3) Vector spaces, linear transformations, integration, Fourier and Laplace transforms, distributions, differential operators. Prerequisite: MATH 401 or 411 or 412.

506. Fundamentals of Applied Mathematics II (3) Integral equations, compact operators, variational methods, partial differential equations. Prerequisite: MATH 505.

507. Fundamentals of Applied Mathematics III (3) Nonlinear equations, asymptotic methods. Prerequisite: MATH 406.

508. Integral Equations (3) Fredholm and Volterra equations and applications. Prerequisite: MATH 401 or 411 or 412.

509. Distributions and Generalized Functions (3) Schwartz-Sobolev theory of distributions, tempered distributions, Fourier transforms, fundamental solutions of ordinary and partial differential equations; applications. Prerequisite: MATH 401 or 412 or 430.

510. Calculus of Variations and Optimal Control (3) Classical and modern theory of the calculus of variations; problems in optimal control. Prerequisite: MATH 401 or 411 or 412.

511-512. Ordinary Differential Equations (3 each) Linear spaces and operators, existence and uniqueness of solutions, linear systems. Green's functions, eigenvalue problems — including Fourier series. Prerequisite: MATH 250 or 251 or 411.

513. Partial Differential Equations of Mathematical Physics I (3) Methods of solution of selected elliptic, parabolic, and hyperbolic partial differential equations, with reference to physical application. Prerequisite: MATH 411 or 412.

514. Partial Differential Equations of Mathematical Physics II (3) Elliptic operators, fundamental solutions, weak and strong derivatives, Sobolev inequalities, Dirichlet problem, equations of evolution, semi-groups. Prerequisite: MATH 513.

516. (STAT 516) Stochastic Processes (3) Markov chains; generating functions; limit theorems; continuous time and renewal processes; martingales, submartingales, and supermartingales; diffusion processes; applications. Prerequisite: MATH (STAT) 416.

517. (STAT 517) Probability Theory (3) Measure theoretic foundation of probability, distribution functions and laws, types of convergence, central limit problem, conditional probability, special topics. Prerequisite: MATH 501.

518. (STAT 518) Probability Theory (3) Measure theoretic foundation of probability, distribution functions and laws, types of convergences, central limit problem, conditional probability, special topics. Prerequisite: MATH 517.

519. (STAT 519) Topics in Stochastic Processes (3) Selected topics in stochastic processes, including Markov and Wiener processes; stochastic integrals, optimization, and control; optimal filtering. Prerequisites: MATH (STAT) 516, 517.

520. Projective Geometry (3) General study of the subject from the synthetic and analytic standpoint. Prerequisites: MATH 435, 480.

521-522. Complex Analysis (3 each) Analytic and meromorphic functions; Riemann's mapping theorem. Prerequisite: MATH 402.

523. Theory of Special Functions (3) Topics include asymptotic expansions; Riemann-Papperitz and Trusdell's F equations; orthogonal polynomials; generating, beta, zeta, hypergeometric, Bessel, Legendre, elliptic functions. Prerequisite: MATH 401 or 406 or 521.

524. Advanced Complex Analysis (3) Topics include boundary behavior of analytic functions, bounded analytic functions, conformal mapping, theory of Riemann surfaces. Prerequisite: MATH 522.

525. Theory of Functions of Several Complex Variables (3-6) Topics include fundamental properties of holomorphic functions, complex analytic manifolds, integral representations, Cousin problems. Prerequisite: MATH 522.

526. Differential Geometry (3) Manifolds-differentiable structures, tangent spaces, connections, structural equations. Riemannian geometry. Prerequisite: MATH 429.

527. Complex Differential Geometry (3) Riemann surfaces, bounded domains, complex manifolds, Kahler manifolds, curvatures, Schwartz lemmas, holomorphic mappings. Prerequisites: MATH 521, 526.

528. Uniform Spaces and Function Spaces (3) Uniform spaces, completion, compactifications, function spaces, metrization. Prerequisite: MATH 429.

529. Topology I (3) Topological, product, metric spaces; compactness, local compactness, connected and locally connected spaces, countability conditions, topology of the plane, fundamental groups.

530. Topology II (3) Homotopy theory, introduction to manifolds, singular homology theory, and the axioms of homology. Prerequisite: MATH 529.

531. Algebraic Topology I (3) Higher homotopy groups, fibre spaces, fibre bundles, sheaf cohomology, surgery theory. Prerequisite: MATH 530.

532. Algebraic Topology II (3) Geometric applications of algebraic topology; manifolds, Morse theory, the h-cobordism theorem. Prerequisite: MATH 531.

533-534. Lie Theory (3 each) Topics selected from theory of topological semigroups, topological groups, Lie groups, transformation groups. Prerequisite: MATH 530.

535-536. Algebra (3 each) Permutation groups, Sylow theorems, Jordan-Hölder theorem, polynomial rings, unique factorization domains, algebraic and transcendental field extensions, Galois theory. Prerequisites: MATH 435 and a course in linear algebra (for MATH 535 only); MATH 535 (for MATH 536 only).

537. Field Theory (3) Finite and infinite algebraic extensions; cyclotomic fields; transcendental extensions; bases of transcendence, Luroth's theorem, ordered fields, valuations; formally real fields. Prerequisite: MATH 536.

538. Commutative Algebra (3) Topics selected from Noetherian rings and modules, primary decompositions, Dedekind domains and ideal theory, other special types of commutative rings or fields. Prerequisite: MATH 536.

539-540. Ring Theory (3 each) Selected topics including Noetherian and Artinian modules and rings, semisimple rings, Wedderburn theorems, Jacobson radical and density theorem. Prerequisite: MATH 536 (for MATH 539 only); MATH 539 (for MATH 540 only).

541. Linear Algebra (3) Vector spaces and linear transformations, canonical representations, elementary divisors, and invariant factors. Prerequisite: MATH 436 or 536.

542-543. Group Theory I and II (3 each) Topics selected by instructor from abelian, solvable, and nilpotent groups; finite presentations; free products; group extensions; group representations. Prerequisite: MATH 535 (for MATH 542 only); MATH 542 (for MATH 543 only).

544. Applied Algebra I (3) Basic algorithms of algebra, application to number theory, group theory, field theory, linear algebra, and combinatorics. Prerequisites: MATH 435, 436, and ability to use a computer.

545. Applied Algebra II (3) Analysis and implementation of various algorithms used in current mathematical research. Prerequisite: MATH 544.

546. Semigroup Theory and Applications (3) Basic algebraic properties of semigroups, finite transformation semigroups, free semigroups. Applications to automata theory, formal languages, and combinatorics. Prerequisites: MATH 435, 535.

547. Homological Algebra (3) Modules, diagrams, functors, homology of complexes, resolutions, cohomology of groups, tensor and torsion products. Prerequisite: MATH 536.

548. Advanced Algebra (3-6) Topics vary depending on instructor and demand. Possible topics are multilinear algebra, tensor products, Brauer group, category theory, and K-theory. Prerequisite: MATH 539.

549. Algebraic Geometry (3) Topics may include algebraic curves, the Riemann-Roch theorem, schemes, and sheaf cohomology. Prerequisite: MATH 536.

550. (CMPSC 550) Numerical Algebra (3) Zeros of polynomials; iterative solution of linear and nonlinear systems; sparse matrix techniques: eigenvalues and eigenvectors. Prerequisite: MATH (CMPSC) 454 or MATH 441.

551. (CMPSC 551) Numerical Solution of Ordinary Differential Equations (3) Methods for initial value and boundary value problems. Stability and convergence analysis, automatic error control, and stiff systems. Prerequisites: MATH (CMPSC) 453, MATH 411.

552. (CMPSC 552) Numerical Solution of Partial Differential Equations (3) Methods of parabolic, hyperbolic, and elliptic partial differential equations; finite difference and variational methods; splines, finite elements. Prerequisites: MATH 405; MATH (CMPSC) 453 or 454.

553. (CMPSC 553) Introduction to Approximation Theory (3) Interpolation; remainder theory; approximation of functions; error analysis; orthogonal polynomials; approximation of linear functionals; functional analysis applied to numerical analysis. Prerequisites: MATH 401 and 3 credits of computer science.

554. Approximation Theory (3) Approximation in normed spaces; existence, uniqueness, characterization, computation of best approximations; error bounds; degree of approximation; approximation of linear functionals. Prerequisites: MATH (CMPSC) 453, MATH 501.

555. Theory and Techniques of Optimization (3) Minimization of functionals; convexity, duality, penalty; gradient and conjugate gradient methods; quadratic problems; variational inequalities; optimal control, differential game problems. Prerequisites: MATH (CMPSC) 453, 454.

556. (CMPSC 556) The Finite Element Method in Partial Differential Equations (3) Variational formulations of partial differential equations; algorithms and errors for finite element approximations; isoparametric elements; nonlinear partial differential equations. Prerequisite: MATH 454.

557-558. Mathematical Logic and Foundations of Mathematics I, II (3 each) First-order logic. Completeness and incompleteness theorems of Gödel. Introduction to model theory, axiomatic set theory, computability, and unsolvability. Prerequisites: MATH 457 or consent of instructor (for MATH 557 only); MATH 557 (for MATH 558 only).

559. Recursion Theory I (3) Recursive functions, enumeration theorem, recursion theorem; recursively enumerable sets, the jump operator, arithmetical hierarchy; subrecursive hierarchies, complexity theory; degrees of unsolvability. Prerequisite: MATH 558 or CMPSC 559.

560. Recursion Theory II (3) Continuation of MATH 559: recursively enumerable sets, degrees of unsolvability, hierarchy theory, inductive definitions, recursion in higher types. Prerequisite: MATH 559.

561. Set Theory I (3) Models of set theory, constructible sets, forcing, large cardinals and elementary embeddings; introduction to descriptive set theory; introduction to infinitary combinatorics. Prerequisite: MATH 558.

562. Set Theory II (3) Continuation of MATH 561. Large cardinals, indiscernibles, iterated ultrapowers; iterated forcing, infinitary combinatorics, trees; descriptive set theory, the axiom of determinacy. Prerequisite: MATH 561.

563. Model Theory I (3) Compactness and upward Lowenheim-Skolem theorems, interpolation, and definability; element types, saturation, indiscernibles, omitting types theorems; applications to algebra. Prerequisite: MATH 558.

564. Model Theory II (3) Continuation of MATH 563. Ultrapowers, categoricity, infinitary logic, stability and superstability; other topics; applications to algebra. Prerequisite: MATH 563.

565. Number Theory I (3) Congruences, quadratic residues, arithmetic functions, partitions, classical multiplicative ideal theory, valuations and p-adic numbers; primes in arithmetic progression, distribution of primes. Prerequisite: MATH 435.

566. Number Theory II (3) Congruences, quadratic residues, arithmetic functions, partitions, classical multiplicative ideal theory, valuations and p-adic numbers; primes in arithmetic progression, distribution of primes. Prerequisite: MATH 565. Prerequisite or concurrent: MATH 521.

567. Number Theory III (3) Higher order residues, Fermat's "Last Theorem" for regular primes, formulae for class number of cyclotomic and quadratic extensions, partition congruences. Prerequisite: MATH 566.

568. Algebraic Number Theory I (3) Dedekind rings; cyclotomic and Kummer extensions; valuations; ramification, decomposition, inertial groups; Galois extensions; locally compact groups of number theory. Prerequisites: MATH 536, 566.

569. Algebraic Number Theory II (3) Local and global class field theory; integral quadratic forms; algebraic and arithmetic groups; algebraic function of one variable. Prerequisite: MATH 568.

570. Analytic Number Theory I (3) Improvements of the prime number theorem, L-functions and class numbers, asymptotic and arithmetic properties of coefficients of modular forms. Prerequisites: MATH 521, 566.

571. Analytic Number Theory II (3) Distribution of primes, analytic number theory in algebraic number fields, transcendental numbers, advanced theory of partitions. Prerequisite: MATH 570.

572. Special Topics in Algebra (3-12)

573. Special Topics in Applied Mathematics (3-12)

574. Topics in Mathematical Logic and the Foundations of Mathematics (3-6) Prerequisite: MATH 558.

575. Special Topics in Number Theory (3-12)

576. Special Topics in Analysis (3-12)

578. Special Topics in Topology (3-12)

579. (CMPSC 579) Special Topics in Numerical Analysis (2-12)

580. Special Topics in Geometry (3-12)

587. Special Topics in Combinatorics (3 per semester, maximum of 6) Topics selected from the theories of enumeration and construction of combinatorial structures. Prerequisites: MATH 435, 436, 465.

590. Colloquium (1-3)

591-592. Mathematics Seminar (1-6) Selected topics from recent mathematical developments.

596. Individual Studies (1-9)

597. Special Topics (1-9)

602. Supervised Experience in College Teaching (1-3 per semester, maximum of 6)

MECHANICAL ENGINEERING (M E)

HAROLD R. JACOBS, *Head of the Department*
207 Mechanical Engineering Building
814-865-2519

Degrees Conferred: Ph.D., M.S., M.Eng.

Senior Members of the Graduate Faculty
Fan-Bill Cheung, Ph.D. (Notre Dame) *Associate Professor of Mechanical Engineering*
Gerard M. Faeth, Ph.D. (Penn State) *Professor Emeritus of Mechanical Engineering*
Robert J. Heinsohn, Ph.D. (Michigan State), P.E. *Professor of Mechanical Engineering*
Robert E. Henderson, Ph.D. (Cambridge), P.E. *Professor of Mechanical Engineering*
John J. Henry, Sc.D. (MIT) *Professor of Mechanical Engineering*
Harold R. Jacobs, Ph.D. (Ohio State), P.E. *Professor of Mechanical Engineering*
Bohdan Kulakowski, Ph.D. (Inst. of Applied Cybernetics) *Associate Professor of Mechanical Engineering*
Anil K. Kulkarni, Ph.D. (Brown) *Associate Professor of Mechanical Engineering*
Kenneth K. Kuo, Ph.D. (Princeton) *Professor of Mechanical Engineering*
Brian E. Launder, Sc.D. (MIT) D.Sc. (London) *Adjunct Professor of Mechanical Engineering*
Samuel S. Lestz, Ph.D. (Wisconsin) *Professor Emeritus of Mechanical Engineering*

Charles L. Merkle, Ph.D. (Princeton) *Professor of Mechanical Engineering*
Michael F. Modest, Ph.D. (California-Berkeley) *Professor of Mechanical Engineering*
William H. Park, Ph.D. (Cornell) *Professor of Mechanical Engineering*
Asok Ray, Ph.D. (Northeastern) *Associate Professor of Mechanical Engineering*
Gerhard Reethof, Sc.D. (MIT) *Professor of Mechanical Engineering*
Domenic A. Santavicca, Ph.D. (Princeton) *Associate Professor of Mechanical Engineering*
Robert J. Santoro, Ph.D. (Boston College *Associate Professor of Mechanical Engineering*
Frank W. Schmidt, Ph.D. (Wisconsin) *Professor of Mechanical Engineering*
Gary S. Settles, Ph.D. (Princeton) *Associate Professor of Mechanical Engineering*
H. Joseph Sommer III, Ph.D. (Illinois) *Associate Professor of Mechanical Engineering*
Martin W. Trethewey, Ph.D. (Michigan Tech.) *Associate Professor of Mechanical Engineering*
Stephen R. Turns, Ph.D. (Wisconsin) *Associate Professor of Mechanical Engineering*
James C. Wambold, Ph.D. (New Mexico) *Professor of Mechanical Engineering*
Ralph L. Webb, Ph.D. (Minnesota) *Professor of Mechanical Engineering*
Carl H. Wolgemuth, Ph.D. (Ohio State) *Professor of Mechanical Engineering*
Savas Yavuzkurt, Ph.D. (Stanford) *Associate Professor of Mechanical Engineering*

Associate Members of the Graduate Faculty
Ashok D. Belegundu, Ph.D. (Iowa) *Assistant Professor of Mechanical Engineering*
John M. Cimbala, Ph.D. (Cal. Tech.) *Assistant Professor of Mechanical Engineering*
Brian J. Gilmore, Ph.D. (Purdue) *Assistant Professor of Mechanical Engineering*
Thomas G. Hughes, Ph.D. (Penn State) *Research Associate, Applied Research Laboratory*
Suresh M. Joshi, Ph.D. (Rensselaer) *Adjunct Professor of Mechanical Engineering*
John S. Lamancusa, Ph.D. (Wisconsin-Madison), P.E. *Assistant Professor of Mechanical Engineering*
Thomas A. Litzinger, Ph.D. (Princeton) *Assistant Professor of Mechanical Engineering*
Oliver H. McDaniel, Ph.D. (Penn State) *Research Associate, Applied Research Laboratory*
Howard L. Petrie, Ph.D. (Illinois) *Research Associate, Applied Research Laboratory*
Alok Sinha, Ph.D. (Carnegie-Mellon) *Assistant Professor of Mechanical Engineering*
Richard B. Smith, Ph.D. (Penn State) *Research Associate, Applied Research Laboratory*
Donald A. Streit, Ph.D. (Purdue) *Assistant Professor of Mechanical Engineering*
Stefan T. Thynell, Ph.D. (North Carolina State) *Assistant Professor of Mechanical Engineering*
Uri Tsach, Ph.D. (MIT) *Assistant Professor of Mechanical Engineering*
Jeremy L. Walter, Ph.D. (Penn State) *Research Associate, Applied Research Laboratory*
Vigor Yang, Ph.D. (Cal. Tech.) *Assistant Professor of Mechanical Engineering*

Graduate programs and research facilities are available in thermodynamics and combustion, heat transfer, fluid mechanics, dynamic system analysis, robotics, mechanical design, and energy systems. Air pollution control, automotive safety, designing for noise control and for reliability also provide many research and design opportunities.

Admission Requirements
Scores from the Graduate Record Examination (GRE), or from a comparable substitute examination accepted by a graduate program and authorized by the dean of the Graduate School, are required for admission. At the discretion of a graduate program, a student may be admitted provisionally for graduate study in a program without these scores. Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin.*

The entering student must hold a bachelor's degree in engineering or physical science. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

Degree Requirements
A student working toward an M.S. degree may choose one of the following options: (1) a minimum of 24 course credits plus 6 thesis credits (M E 600) culminating in the submission of a thesis to the Graduate School; (2) a minimum of 30 course credits plus a technical report; or (3) a minimum of 30 course credits plus submission of a Ph.D. thesis research proposal, provided the student has passed the Ph.D. candidacy examination.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by an in-depth study of one foreign language (6 credits), by taking two or more courses (minimum of 6 credits) of a nontechnical nature in a single area of study appropriate and related to the student's career orientation, or by taking an advanced technical writing course (ENGL 418 — 3 credits) and presenting a formal proposal for thesis research to the doctoral committee.

Continuous registration is required of all graduate students until the thesis or engineering report is approved.

Student Aid

In addition to the fellowships, traineeships, graduate assistantships, and other forms of financial aid described in the STUDENT AID section of the *Graduate Bulletin,* the following awards typically have been available to graduate students in this program:

AFRAPT (Air Force Research in Aero Propulsion Technology) Traineeship — Available to an outstanding Ph.D. degree student. The student must hold a B.S. degree in mechanical or aerospace engineering, another appropriate engineering field, or in physics, and must be accepted by a faculty member as a research trainee on an externally funded research project. Applications and information can be obtained from the Department of Mechanical Engineering, 207 Mechanical Engineering Building. Application deadline is December 31.

Dean's Fellowships — Available to outstanding Ph.D. degree students who have secured assistantship appointments in the department. Amount of the award varies. Information can be obtained from the Office of the Dean, College of Engineering, 101 Hammond Building.

MECHANICAL ENGINEERING (M E)

403. Rocket Propulsion (3)
405. Air Pollution Control Systems (3)
409. Gas Turbines (3)
410. Power Plants (3)
411. Refrigeration and Air Conditioning (3)
412. Heat Transfer (3)
413. Internal Combustion Engines (3)
414. Engineering Analysis of Thermal Systems (3)
415. Engineering Analysis for Mechanical Design (3)
417. Theory of Engineering Instruments (3)
418. Principles of Turbomachinery (3)
420. Heat-Exchanger Design (3)
421. (AERSP 421) Intermediate Viscous Flow (3)
435. Fluid Mechanics and Mechanical Vibration Laboratory (3)
440. Modeling of Dynamic Systems (3)
450. Design of Machine Tools (3)
451. Advanced Machine Design Problems (3)
452. Design Analysis (3)
454. Advanced Machine Dynamics (3)
455. Automatic Control Systems (3)
456. (I E 456) Industrial Robot Applications (3)
458. Noise Control in Machinery (3)
460. Reliability Concepts in Design (3)
461. (E MCH 461) Applied Finite Element Analysis (3)
462. Microcomputer Interfacing for Mechanical Engineers (3)
466H. Fundamentals of Computer Graphics (3)
470. Fundamentals of Air Pollution (3)
494. Senior Thesis (1-9)
496. Independent Studies (1-18)
497. Special Topics (1-9)

503. Thermodynamic Process Analysis (3) Development of equations governing separate processes in complete machines to give basic system parameters and characteristics; transient processes; irreversible effects.

504. Advanced Engineering Thermodynamics (3-6) Pure and applied thermodynamics including its application to advanced engineering problems; collateral reading and discussion of the classical works on the subject.

505. Design of Air Pollution Control Systems (3) Advanced principles of design drawn from professional literature, including mechanical collectors, electrostatic precipitators, filters, scrubbers, and industrial ventilation systems. Prerequisite: M E 405.

512. Heat Transfer — Conduction (3) One- and two-dimensional conduction heat transfer for steady state and transient systems with varying boundary conditions.

513. Heat Transfer — Convection (3) Laminar and turbulent flow heat transfer in natural and forced convection systems.

514. Heat Transfer — Radiation (3) Thermal radiation fundamentals; specular and diffuse systems; differential and integral methods; numerical techniques; industrial applications.

515. Two-Phase Heat Transfer (3) Heat transfer processes involving evaporation, boiling, and condensation.

516. Combustion in Propulsion Systems (3) Theoretical formulations and methods of solution of engineering problems and physical processes in chemical propulsion systems.

517. Techniques for Heat Transfer Enhancement (3) Study of advanced concepts in convective and two-phase heat transfer, with emphasis on techniques of heat transfer enhancement. Prerequisites: M E 033, 412.

518. Analysis of Heat Exchanger Equipment (3) Application of theoretical fundamentals to the design of heat exchange equipment, and the analysis of simultaneous heat and mass transfer processes. Prerequisite: M E 513 or 515.

519. Compressible Fluid Flow (2-4) Two-dimensional subsonic flow; similarity rules; theory of characteristics; supersonic and hypersonic flows; nonsteady flow; oblique shock waves.

521. Electromagnetic and Thermodynamic Flow Systems (3) Thermodynamic equations for flow of reacting and nonreacting fluids in electromagnetic fields; applications to engineering problems.

522. Boundary Layer and Separated Flows (3) Behavior of viscous fluids, with emphasis on boundary layer and separation effects in internal flow.

526. (AERSP 526) Computational Methods for Shear Layers (3) Study of numerical solution methods for steady and unsteady laminar or turbulent boundary-layer equations in two and three dimensions. Prerequisite: M E 540 or AERSP 423.

527. (AERSP 527) Computational Methods in Transonic Flow (3) Numerical solution of partial differential equations of mixed type, with emphasis on transonic flows and separating boundary layers. Prerequisite: M E 540 or AERSP 423.

528. (AERSP 528) Computational Methods for Recirculating Flows (3) Numerical solution techniques for laminar/turbulent flow with large recirculation zones. Both primitive variable and stream function-vorticity equations used. Prerequisites: AERSP 423, M E 540.

530. Species Measurements in Combustion Systems (1-3) Study of modern instrumentation techniques for determination of species concentrations in combustion systems.

532. Turbulent and Two-Phase Combustion (3) Fundamentals of chemically reacting turbulent flows in homogeneous systems, including turbulent flames, spray combustion, ignition, reacting boundary layers. Prerequisite: F SC 421 or M E 516.

535. Physics of Gases (3) An introduction to kinetic theory, statistical mechanics, quantum mechanics, atomic and molecular structure, chemical thermodynamics, and chemical kinetics.

536. Laser Doppler Velocimetry (1) A study of methods for measuring velocities, turbulence quantities, and particle sizes employing laser light scattering principles.

537. Laser Diagnostics for Combustion (2) A study of laser-based techniques for measuring gas temperature and concentration in chemically reacting flows. Prerequisite: M E 535.

540. Numerical Solutions Applied to Heat Transfer and Fluid Mechanics Problems (3) Application of finite difference methods to the study of potential and viscous flows and conduction and convection heat transfer.

552. Advanced Dynamics of Machines (3-6) Linear and torsional vibrations in and balancing of rotating and reciprocating machinery; exact analysis of stresses produced by these and other dynamic forces in machine parts. Prerequisites: E MCH 012, M E 054.

554. Experimental Modal Analysis (3) The development of structural dynamic models from experimental data, analytical and experimental vibration, analysis methods, laboratory techniques. Prerequisite: M E 440.

555. Automatic Control Systems (3) Advanced problems and techniques in the design of automatic control systems with emphasis on stability, controller design, and optimum performance. Prerequisite: M E 455.

556. (I E 556) Robotic Concepts (3) Analysis of robotic systems; end effectors, vision systems, sensors, stability and control, off-line programming, simulation of robotic systems. Prerequisite: M E 456 or I E 456.

557. Mechanism Synthesis (3) Geometrical and algebraic methods for synthesizing planar and spatial mechanisms, dynamics of spatial mechanism.

558. Fluid Control Systems (2) Modeling fluid system dynamic performance, experimental determination of the actual behavior, and comparison of predicted behavior with actual behavior. Prerequisite: M E 455.

559. (E E 559) Nonlinear Control and Stability (3) Design of nonlinear automatic control systems; phase-plane methods; describing functions; optimum switched systems; Liapunov stability; special topics in stability. Prerequisite: E E 417 or 428 or M E 455.

560. Digital Process Control (3) Analysis and design of control systems with digital controllers, including PID, finite settling time, state feedback, and minimum variance algorithms. Prerequisites: M E 440, 455.

561. Stochastic Systems for Mechanical Engineering (3) Linear multidimensional dynamical systems with stochastic disturbances; fundamentals of decision and estimation theory; examples using problems in mechanical engineering. Prerequisites: M E 455, STAT 414.

562. Simulation of Mechanical Systems (3) Introduces computational fundamentals, including digital logic; programming language, basic numerical analysis and data processing, as applied to mechanical simulation techniques. Prerequisites: M E 054, 066.

563. (M E 563) Nonlinear Finite Elements (3) Advanced theory of semidiscrete formulations for continua and structures; emphasizes dynamic and nonlinear problems. Prerequisite: E MCH 461 or 560 or AG E 513.

565. Optimal Design of Mechanical and Structural Systems (3) Application of numerical optimization techniques to design of mechanical and structural systems; design sensitivity analysis.

571. Air Pollution Seminars (1-2) Weekly seminars featuring the contributions of many different disciplines to the solution of air pollution and other environmental problems.

596. Individual Studies (1-9)

597. Special Topics (1-9)

602. Supervised Experience in College Teaching (1-3 per semester, maximum of 6)

METALS SCIENCE AND ENGINEERING (METAL)

DONALD A. KOSS, *In Charge of Graduate Programs in Metals Science and Engineering*
209 Steidle Building
814-865-5446

Degrees Conferred: Ph.D., M.S.

Senior Members of the Graduate Faculty
William R. Bitler, Ph.D. (Carnegie Tech.) *Professor of Metallurgy*
Tarasankar Deb Roy, Ph.D. (Inst. of Science, Bangalore) *Associate Professor of Metallurgy*
John H. Hoke, D.Eng. (Johns Hopkins) *Professor Emeritus of Metallurgy*
Arnulf I. Muan, Ph.D. (Penn State) *Professor of Geochemistry*
Kwadwo Osseo-Asare, Ph.D. (California) *Professor of Metallurgy*
Howard W. Pickering, Ph.D. (Ohio State) *Professor of Metallurgy*
Earle R. Ryba, Ph.D. (Iowa State) *Associate Professor of Metallurgy*
George Simkovich, Ph.D. (Penn State) *Professor of Materials Science*
Peter A. Thrower, Ph.D. (Cambridge) *Professor of Materials Science*

Associate Members of the Graduate Faculty
Lee Cuddy, Ph.D. (Columbia) *Associate Professor of Metallurgy*
Paul R. Howell, Ph.D. (Cambridge) *Associate Professor of Metallurgy*
W. Murray Small, Ph.D. (Michigan) *Associate Professor of Metallurgy*

This program is one in which a graduate student in the Department of Materials Science and Engineering can receive an advanced degree. Suitable preparation for graduate study in this program can be obtained in various science and engineering majors as well as metallurgy. A student may specialize, through both course work and research, in the science and engineering aspects of both the processing and properties of metals.

Faculty expertise and research facilities permit particular emphasis in areas such as wet corrosion, oxidation, laser processing, phase transformations, deformation and fracture, aqueous processing, powder processing, and structure characterization studies. Courses relevant to the Metals Science and Engineering program, laboratory facilities, and faculty interaction with other departments broaden the scope of program possibilities.

Admission Requirements
Scores from the Graduate Record Examination (GRE) are not required for admission, but applicants are strongly advised to submit them with their application. Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin.*

Master's Degree Requirements
Students who want to obtain the M.S. degree in Metals Science and Engineering must take 18 credits of formal course work. All graduate students are expected to contribute to the instructional program. A thesis and thesis examination are part of the degree requirements.

Doctoral Degree Requirements
Students who want to pursue the Ph.D. degree usually must complete an acceptable M.S. degree. Admission to Ph.D. candidacy shall be based on acceptable performance in the candidacy examination and performance within the program as based on a recommendation and evaluation by the appropriate thesis adviser and faculty commmittee. With few exceptions, all Ph.D. candidates will take at least 12 credits of course work in addition to those required for the master's degree. Subsequent to the B.S. degree, at least 18 credits of formal courses must be taken at the 500 level in metals science and engineering and related fields. Satisfactory performance on the Ph.D. comprehensive examination, which is based on the student's thesis subject, also is required. All graduate students are expected to contribute to the instructional program.

Student Aid
Graduate assistantships available to students in this program and other forms of student aid are described in the STUDENT AID section of the *Graduate Bulletin.*

METALS SCIENCE AND ENGINEERING (METAL)

400. Corrosion Forms and Prevention (3)
402. Corrosion Engineering (2)
404. Thermochemical Processing (3)
405. Phase Transformations in Metals and Alloys (3)
406. Deformation, Fracture, and Alloy Design (3)
408. Processing of Metals (3)
410. Metallurgical Investigations and Design (1-6)
416. Hydrometallurgy Laboratory (1)
426. (MN PR 426) Aqueous Processing (3)
434. Metallurgy Laboratory I (1)
435. Metallurgy Laboratory II (1)
436. Metallurgy Laboratory III (1)
496. Independent Studies (1-18)
497. Special Topics (1-9)

501. Metallurgical Problems (1-6 per semester) Independent study of special problems in metallurgy.

505. Oxidation of Metals (3) The course will cover high-temperature oxidation of metals and alloys including Wagner's theories of internal oxidation. Prerequisite: CHEM 451. *Simkovich*

507. (MN PR 507) Hydrometallurgical Processing (3) Fundamental physico-chemical factors underlying the aqueous extraction and recovery of metals and nonmetals from ores, minerals, and scrap metal. Prerequisite: METAL (MN PR) 426. *Osseo-Asare*

508. Kinetics of Phase Transformations (3) Application of statistical mechanics and absolute rate theory to kinetics of phase transformations, including diffusion, nucleation, and growth rates. *Bitler*

509. Introductory Theoretical Physical Metallurgy (3) Quantum mechanics and its application to solid-state theory; introduction of Schroedinger's equation, its solutions, free-electron model, band model. *Bitler*

510. Magnetic and Transport Properties of Materials (3) Treatment of the magnetic and transport properties of solids by quantum mechanics with applications to practical alloy development. Prerequisite: METAL 509. *Bitler*

513. Advanced Chemical Metallurgy I (3) Application of thermodynamics and kinetics to the heterogeneous metallurgical processes of oxidation, reduction, smelting, and refining. Prerequisite: METAL 404. *Small*

514. Dislocation Theory (3) Self and interaction energies of dislocations and other defect structures; dislocation motions and their relation to mechanical properties. *Bitler*

515. Corrosion of Metals (3) Phenomena and theories of metallic corrosion; principles of alloy selection for engineering and structural uses in corrosive environments. *Pickering*

517. Metal Electrode Reactions (2-3) Evaluation of electrode reaction mechanisms at metal/water and metal/oxide/water interfaces relevant to corrosion and industrial electrolytic processes. Prerequisites: CHEM 451. *Pickering*

519. Advanced Chemical Metallurgy II (3) Application of thermodynamics and kinetics to precipitation of nonmetallic and metallic phases from liquid and solid metals at elevated temperatures. Prerequisite: METAL 513. *Deb Roy*

522. Solid-Phase Reactions in Metals (3) Mechanisms and rate-determining factors in solid-phase reactions in metals; diffusion processes, nucleation theory, precipitations from solid solution, eutectoid decomposition and order-disorder phenomena. Prerequisite: METAL 508. *Howell*

534. (E MCH 534) Micromechanisms of Fracture (3) Mechanisms of fracture and their relationship to loading conditions, environment, flow behavior, processing history, and microstructure. Prerequisites: E EC 414H, METAL 406.

535. (E MCH 535) Crystal Defects and Deformation (3) Deformation of crystalline solids containing defects; elastic and plastic responses over a range of temperatures and strain rates. Prerequisite: E SC 414H or METAL 406.

590. Colloquium (1-3)

597. Special Topics (1-9)

602. Supervised Experience in College Teaching (1-3 per semester, maximum of 6)

Note: *Courses in introductory thermodynamics and kinetics of metals and the use of X-ray diffraction, electron microscopy, and spectroscopy in metallurgical studies are listed under MATERIALS SCIENCE.*

METEOROLOGY (METEO)

WILLIAM M. FRANK, *Head of the Department*
503 Walker Building
814-865-0478

Degrees Conferred: Ph.D., M.S.

Senior Members of the Graduate Faculty
Bruce A. Albrecht, Ph.D. (Colorado State) *Associate Professor of Meteorology*
Alfred K. Blackadar, Ph.D. (NYU) *Professor Emeritus of Meteorology*
Craig F. Bohren, Ph.D. (Arizona) *Professor of Meteorology*
John J. Cahir, Ph.D. (Penn State) *Professor of Meteorology*
Toby N. Carlson, Ph.D. (Imperial College-London) *Professor of Meteorology*
John H. E. Clark, Ph.D. (Florida State) *Associate Professor of Meteorology*
Rosa G. de Pena, Ph.D. (Buenos Aires) *Professor Emerita of Meteorology*
John A. Dutton, Ph.D. (Wisconsin) *Professor of Meteorology*
Christopher W. Fairall, Ph.D. (Michigan State) *Associate Professor of Meteorology*
Gregory S. Forbes, Ph.D. (Chicago) *Associate Professor of Meteorology*
William M. Frank, Ph.D. (Colorado State) *Associate Professor of Meteorology*
Alistair B. Fraser, Ph.D. (Imperial College-London) *Professor of Meteorology*
J. Michael Fritsch, Ph.D. (Colorado State) *Professor of Meteorology*
Charles L. Hosler, Ph.D. (Penn State) *Professor of Meteorology*
John J. Olivero, Ph.D. (Michigan) *Professor of Meteorology*
Hans A. Panofsky, Ph.D. (California-Berkeley) *Evan Pugh Research Professor Emeritus of Atmospheric Sciences*
Nelson L. Seaman, Ph.D. (Penn State) *Assistant Professor of Meteorology*
Hampton N. Shirer, Ph.D. (Penn State) *Associate Professor of Meteorology*
Dennis W. Thomson, Ph.D. (Wisconsin) *Professor of Meteorology*
Thomas T. Warner, Ph.D. (Penn State) *Associate Professor of Meteorology*
Peter J. Webster, Ph.D. (MIT) *Professor of Meteorology*

Associate Members of the Graduate Faculty
Peter R. Bannon, Ph.D. (Colorado) *Associate Professor of Meteorology*
Dennis Lamb, Ph.D. (Washington) *Associate Professor of Meteorology*
George S. Young, Ph.D. (Colorado) *Assistant Professor of Meteorology*

The graduate program embraces topics that span atmospheric processes from those of the planetary boundary layer to those of the upper atmosphere, that encompass phenomena with molecular to planetary dimensions, and that range from practical to theoretical significance. The program attempts to develop and integrate approaches based on observational, computational, and analytical techniques.

The major interests of the faculty and graduate students center on (1) analysis, modeling, and prediction of the evolution of synoptic scale and mesoscale weather systems, particularly those of significant impact on human activities; (2) observation and theoretical study of processes related to transmission of radiation through the atmosphere, including remote sensing through use of electromagnetic or acoustic systems; (3) theoretical study of atmospheric dynamics on a variety of scales, including nonlinear phenomena of atmospheric circulation and climate, boundary layer physics, turbulence, and convective systems.

The department encourages interdisciplinary studies and is expanding its programs in agricultural meteorology, biometeorology, environmental quality, and mathematical study of fluid dynamical systems.

Admission Requirements
Scores from the Graduate Record Examination (GRE), are required for the evaluation of all applicants. Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin.*

Other requirements for admission include mathematics through differential equations and one year of college physics. Undergraduate study of meteorology is not required for admission. Special programs are available to encourage the graduate study of meteorology by all students with strong backgrounds in mathematics, physics, or engineering. Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

Master's Degree Requirements

The Master of Science degree program comprises instructional and research components. Proficiency in the fundamental concepts of synoptic, dynamic, and physical meteorology is attained in the 12-credit core curriculum composed of METEO 521, 531, and 541; a letter grade of at least B must be attained in each of these three courses. At least 12 additional credits must be taken in 400- or 500-level course work, and at least 3 of these credits must be taken in a 500-level meteorology course. The degree is offered with both thesis and research paper options; those students who are writing a thesis will take 6 credits of METEO 600, and those who write a paper will take an additional 6 credits of 500-level course work.

Doctoral Degree Requirements

Studies for the Ph.D. degree are designed to accommodate the interests and capabilities of the candidate by a doctoral committee, which also administers comprehensive and final examinations. Before being admitted to Ph.D. candidacy, a student must satisfy the same proficiency requirements as those above for M.S. students, have the intellectual support of a faculty member, and have demonstrated high proficiency in both written and spoken English.

Other Relevant Information

The program differentiates between instruction and research topics appropriate for M.S. students seeking positions of advanced responsibility in government or industry, those appropriate for M.S. students anticipating further study, and those appropriate for Ph.D. candidates who will work in advanced research laboratories or academic institutions.

Student Aid

Graduate assistantships available through this program and other forms of student aid are described in the STUDENT AID section of the *Graduate Bulletin*. Most graduate students are supported with teaching or research assistantships.

METEOROLOGY (METEO)

401. Introduction to Dynamic and Synoptic Meteorology (3)
402. Introductory Physical Meteorology (3)
411. Synoptic Meteorology Laboratory (4)
411H. Synoptic Meteorology Laboratory Honors (4)
412. Advanced Synoptic Analytical Techniques (4)
414. Mesoscale Analysis and Forecasting (3)
415. Forecasting Practicum (3)
421. Dynamic Meteorology I (3)
421H. Dynamic Meteorology Honors (3)
422. Dynamic Meteorology II (3)
423. Foundations of Atmospheric Prediction (3)
431. Atmospheric Thermodynamics (3)
432. Atmospheric Chemistry and Physics of Clouds (3)
435. Radiative Transfer (3)
451. Elements of Physical Oceanography (3)
452. Tropical Meteorology (3)
454. Introduction to Micrometeorology (3)
461. Theory of Meteorological Instruments (3)
465. Middle Atmosphere Meteorology (3)
471. Observing Meteorological Phenomena (3)
472. Topics in Climatology (3)
474. Applications of Statistics to Meteorology (3)
476. (GEOSC 402) Natural Disasters Seminar (2)
496. Independent Studies (1-18)
497. Special Topics (1-9)

512. Advanced Meteorological Analysis (4) Graduate version of topics covered in METEO 412. Prerequisites: METEO 411 or 411H; METEO 421 or 421H.

521. Dynamic Meteorology and Applications (4) Graduate core course covering equations of motion, scale analysis and approximate systems, wave and instability theory, nonlinear dynamics, and applications. Prerequisite: METEO 421.

522. Dynamic Meteorology (3) Graduate version of topics covered in METEO 422. Prerequisite: METEO 421H.

525. Theory of Atmospheric Motions (3) Kinematic concepts, axiomatic basis of the equations of motion, dimensional analysis, approximate systems, stability analysis, and nonlinear dynamics. Prerequisite: METEO 521.

526. Numerical Weather Prediction (3) Finite difference and spectral methods, barotropic and baroclinic models, filtered and primitive equation models, synoptic-scale and mesoscale models. Prerequisite: METEO 422 or 522.

527. Atmospheric Wave Motion (3) From classical and physical hydrodynamics to the numerical prediction of wave motion in a baroclinic atmosphere. Prerequisite: METEO 521.

528. Analytical Atmospheric Dynamics (3) Conservation principles, energy conversion processes, dynamics in phase space, introduction to metamodeling. Prerequisite: METEO 521.

529. Mesoscale Dynamics (3) A survey of concepts of mesoscale systems, including frontogenesis, symmetric instability, mountain waves, wave CISK, and frontal waves. Prerequisite: METEO 521.

531. Physical Meteorology and Applications (4) Graduate core course covering elements of radiative transfer, atmospheric structure, thermodynamics, cloud physics, aerosols, and remote sensing. Prerequisite: METEO 431.

532. Chemistry of the Atmosphere (2) Fundamental knowledge of chemical characteristics of atmospheric components and transformations, in connection with cloud microphysics, circulation, and air pollution. Prerequisite: 3 credits in chemistry.

533. Cloud Physics (2) Current theories on phase changes in clouds and mechanisms responsible for precipitation; techniques of cloud modification and control.

536. Indirect Atmospheric Probing (3) Review of Doppler radar (VHF to mm wave) and sonar measurement techniques for studies of boundary layer, tropospheric and stratospheric structure and dynamics.

541. The Earth System (4) Graduate core courses covering the dynamical and physical aspects of the interacting subsystems within the earth system. Prerequisites: METEO 521, 531.

551. Dynamic Oceanography (2) Physical properties of sea water; heat balance of the oceans; theory and observations of ocean currents, waves, and tides.

554. Atmospheric Turbulence (3) Atmospheric diffusion, heat conduction, friction, and evaporation; statistical properties of turbulence.

555. Atmospheric Diffusion (2-3) Dispersion of atmospheric contaminants; experiments, theory, and practical implications for air pollution problems. Prerequisite: 3 credits in statistics.

562. Theoretical Climatology (2) Theory of latitudinal, annual, and diurnal temperature changes; theories of climatic changes, microclimate.

563. Bioclimatology (3) Climatic phenomena in their relation to life.

565. Physics of the Upper Atmosphere (3) Graduate version of material that is covered in METEO 465. Prerequisites: METEO 421, 431.

570. Nonlinear Dynamics Seminar (1-3 per semester, maximum of 15) Review of mathematical techniques used in nonlinear hydrodynamic studies; topics vary each semester but include ongoing departmental research.

571. Mesoscale Dynamics Seminar (1-3 per semester, maximum of 15) An ongoing survey of current theories of mesoscale circulation systems.

574. Atmospheric Dynamics Seminar (1-3 per semester, maximum of 15) A weekly seminar course that focuses on current and past research problems in dynamic meteorology and oceanography.

575. Climate Dynamics Seminar (1-3 per semester, maximum of 15) Review of evolving climate dynamics and earth system science, including ongoing departmental research.

576. Mechanisms for Cyclogenesis (1-3 per semester, maximum of 15) Student/faculty seminar course on cyclogenesis. Prerequisites: METEO 412 or 512; METEO 422.

577. Convective Boundary Layer (1-3 per semester, maximum of 15) Seminar treatment of theory, observations, and modeling of mean and turbulent structures; cloud processes and radiation; air-sea interactions.

578. Convective Weather Systems (1-3 per semester, maximum of 15) Analysis of precipitating convection and the role of convection in atmospheric circulations.

579. Advances in Forecasting Techniques Seminar (1-3 per semester, maximum of 15) Review of recent advances in weather forecasting techniques; topics vary each semester to cover the full spectrum of forecast problems.

581. Topics in Atmospheric Chemistry (1-3 per semester, maximum of 15) Discussion of recent research papers in, and concepts pertinent to, acidic deposition, photochemical air pollution, and global chemical budgets.

582. Ice and Snow Physics (1-3 per semester, maximum of 15) Structure of ice and its electrical, optical, mechanical, and surface properties; snow formation in the atmosphere. Prerequisite: METEO 432.

583. Topics in Atmospheric Measurements (1-3 per semester, maximum of 15) Applications of active and passive remote sensing systems and in-situ systems for measurements of atmospheric parameters, winds, turbulence, and hydrometeors. Prerequisite: METEO 536.

584. Middle Atmosphere Research (1-3 per semester, maximum of 15) A graduate seminar discussing current topics in middle atmospheric research, including measurements, modeling, dynamics, environmental issues, and solar–terrestrial relations.

585. Special topics in Numerical Weather Prediction (1 per semester, maximum of 15) Current topics in numerical weather prediction and related areas are discussed by faculty and students in a seminar setting. Prerequisite: METEO 526.

586. Advances in Numerical Weather Prediction (1-3 per semester, maximum of 15) Recent advances in numerical weather prediction will be discussed by faculty and students. Prerequisite: METEO 526.

590. Colloquium (1-3) Continuing departmental seminar series that consists of individual lectures by faculty, students, or outside speakers.

596. Individual Studies (1-9)

597. Special Topics (1-9)

602. Supervised Experience in College Teaching (1-3 per semester, maximum of 6)

Note: *Courses in the use of X-ray diffraction, electron microscopy, and spectroscopy in meteorological studies are listed under MATERIALS SCIENCE.*

MICROBIOLOGY (MICRB)

EDWIN V. GAFFNEY, *In Charge of Graduate Programs in Microbiology*
S-306 Frear Building
814-863-2093

Degrees Conferred: Ph.D., M.S.

Senior Members of the Graduate Faculty
Donald A. Bryant, Ph.D. (UCLA) *Associate Professor of Molecular and Cell Biology*
Lester E. Casida, Ph.D. (Wisconsin) *Professor of Microbiology*
Richard J. Frisque, Ph.D. (Wisconsin) *Associate Professor of Microbiology*
Edwin V. Gaffney, Ph.D. (Catholic) *Associate Professor of Microbiology and Cell Biology*
Eugene S. Lindstrom, Ph.D. (Wisconsin) *Professor of Microbiology*
Andrea M. Mastro, Ph.D. (Penn State) *Associate Professor of Microbiology and Cell Biology*
Christine F. Pootjes, Ph.D. (Rutgers) *Associate Professor of Microbiology*
Ronald D. Porter, Ph.D. (Duke) *Associate Professor of Microbiology and Molecular Genetics*
Stanley E. Stevens, Ph.D. (Texas) *Associate Professor of Microbiology and Molelcular Biology*
Daniel R. Tershak, Ph.D. (Yale) *Associate Professor of Microbiology*

Arian Zarkower, Ph.D. (Cornell) *Associate Professor of Veterinary Science*
Leonard N. Zimmerman, Ph.D. (Cornell) *Professor of Bacteriology*

Associate Members of the Graduate Faculty
Ming Tien, Ph.D. (Michigan State) *Associate Professor of Biochemistry*
Don M. Wojchowski, Ph.D. (Massachusetts) *Assistant Professor of Molecular and Cell Biology*

The major goal of the program is to train students for independent research and teaching in microbiology. Opportunities for study are available in bacteriology, cell biology, virology, and immunology. Among current areas of research are included bacterial ecology, genetics, and physiology; photosynthesis; chemical and pathogenic properties of both bacterial and animal viruses; viral and tumor immunology; and cancer biology. Cooperative research with other programs is encouraged.

Admission Requirements
Scores from the Graduate Record Examination (GRE), or from a comparable substitute examination accepted by a graduate program and authorized by the dean of the Graduate School, are required for admission. At the discretion of a graduate program, a student may be admitted provisionally for graduate study in a program without these scores. Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin*.

Applicants to the program are expected to have taken courses in biology, general analytical and organic chemistry, calculus, general physics, and microbiology. Admission is competitive and based on evaluation by the admissions committee of the applicant's undergraduate transcript, GRE scores, and personal recommendations. The best-qualified applicants will be accepted up to the number of assistantships available.

Degree Requirements
Beginning students participate in a core curriculum of course work selected by the faculty and spend time rotating through research projects in various laboratories. Students may earn a master's degree in the course of the Ph.D. work or may bypass the master's degree. The master's program requires a minimum of 30 credits, along with preparation and defense of a research thesis, and usually takes two years to complete. Advancement to Ph.D. candidacy is decided on the basis of course and research performance, in addition to a written and oral examination. A comprehensive oral examination and a thesis defense are integral parts of the Ph.D. program. The Ph.D. usually requires four years. All students are required to participate as teaching assistants in undergraduate laboratories as part of their training.

Student Aid
Graduate assistantships available to students in this program and other forms of student aid are described in the STUDENT AID section of the *Graduate Bulletin*.

MICROBIOLOGY (MICRB)

400. Introductory Environmental Microbiology (2)
401. Microbial Physiology and Structure (3)
405. Seminar and Practicum in Medical Technology (15 per semester, maximum of 30)
405A. Seminar and Practicum in Medical Technology (8)
405B. Seminar and Practicum in Medical Technology (1)
405C. Seminar and Practicum in Medical Technology (6)
405D. Seminar and Practicum in Medical Technology (5)
405E. Seminar and Practicum in Medical Technology (7)
405F. Seminar and Practicum in Medical Technology (3)
408. Laboratory Instructional Practice (1-2)
410. Principles of Immunology (2)
411. Survey of Microbiology (1 per semester)
412. Medical Microbiology (3)
413. Microbial Soil Ecology (2)
415. Bacterial and Animal Viruses (3)
416. Industrial Microbiology (2)
421. Laboratory of General and Applied Microbiology (2)
422. Practical Medical Microbiology (2)

435. (M C B 435) Medical Virology (2)
450. (M C B 450) Microbial/Molecular Genetics (2)
460. (M C B 460) Advanced Cell Biology (2)
476. The Photosynthetic Process (2)
480. (M C B 480) Tumor Virology (3)
496. Independent Studies (1-18)
497. Special Topics (1-9)

501. Seminar (1 per semester) Reports on current fields of research.

502. Microbiological Methods (1-6) Practice in special laboratory techniques of modern microbiology.

503. Microbial Physiology (2 per semester, maximum of 4) Modern concepts in physiology and structure of microorganisms. Prerequisites: 6 credits of biochemistry.

504. Virology (2 per semester, maximum of 4) Emphasis on current research. Prerequisites: 6 credits in biochemistry.

505. (M C B 505) Microbial Genetics (2 per semester, maximum of 4) Modern concepts in the genetics of microorganisms. Prerequisite: MICRB 450.

506. Cell Biology (2 per semester, maximum of 4) Emphasis on areas of current research with eucaryotic cells. Prerequisites: 6 credits in biochemistry, 3 credits in cell biology.

507. Immunology (2 per semester, maximum of 4) Discussions of the modern concepts in immunology. Emphasis on areas of current interest. Prerequisites: MICRB 410; 6 credits in biochemistry.

529. (C E 579) Environmental Pollution Microbiology (3) Fundamentals of microorganisms in water and wastewater treatment; indicators of pollution; activities of microorganisms in polluted waters, including biogeochemical cycles. Prerequisite: MICRB 400.

590. Colloquium (1-3)

597. Special Topics (1-9)

602. Supervised Experience in College Teaching (1-3 per semester, maximum of 6)

MICROBIOLOGY (MICRO)

FRED RAPP, *Chair of the Department*
The Milton S. Hershey Medical Center
Hershey, PA 17033
717-531-8253

Degrees Conferred: Ph.D., M.S.

Senior Members of the Graduate Faculty
Gerald L. Bartlett, M.D. (Washington-Seattle); Ph.D. (Pennsylvania) *Professor of Pathology and Microbiology*
Laszlo Geder, M.D., Ph.D. (Debrecen) *Assistant Professor of Medicine and Microbiology*
John N. Goldman, M.D. (Cincinnati) *Professor of Medicine and Microbiology*
Margaret B. Goldman, Ph.D. (Boston) *Associate Professor of Medicine and Microbiology*
Mary K. Howett, Ph.D. (Pennsylvania) *Associate Professor of Microbiology*
Richard W. Hyman, Ph.D. (Cal. Tech.) *Professor of Microbiology*
Harriet C. Isom, Ph.D. (Illinois) *Professor of Microbiology*
John W. Kreider, M.D. (Pennsylvania) *Professor of Pathology and Microbiology*
Fred Rapp, Ph.D. (Southern California) *Professor of Microbiology*
David J. Spector, Ph.D. (Pennsylvania) *Associate Professor of Microbiology*
M. Judith Tevethia, Ph.D. (Michigan State) *Professor of Microbiology*
Satvir S. Tevethia, B.V.Sc. (Agra-India); Ph.D. (Michigan State) *Professor of Microbiology*

Associate Members of the Graduate Faculty
David C. Flyer, Ph.D. (Penn State) *Assistant Professor of Microbiology*
William G. Hendrickson, Ph.D. (Tufts) *Assistant Professor of Microbiology*
Stephen R. Jennings, Ph.D. (Melbourne) *Assistant Professor of Microbiology*

Allan Lipton, M.D. (NYU) *Professor of Medicine and Microbiology*
Richard B. Tenser, M.D. (SUNY-Upstate) *Professor of Medicine and Microbiology*
Brian L. Wigdahl, Ph.D. (Medical College-Wisconsin) *Assistant Professor of Microbiology*

This program is oriented toward the study of viruses and includes programs in viral oncology, viral genetics, tumor immunology, virus gene expression, and virus latency. The regulation of procaryotic gene expression is an additional focus.

Admission Requirements

Scores from the Graduate Record Examination (GRE), or from a comparable substitute examination accepted by a graduate program and authorized by the dean of the Graduate School, are required for admission. Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin*.

Qualified students with undergraduate preparation in the biological, biochemical, or physical sciences may apply. An adequate background in biology, general and organic chemistry, and mathematics and an overall grade-point average of 3.00 or better are required.

The best-qualified applicants will be accepted on a space-available basis. Formal applications should contain two letters of recommendation and a brief personal essay summarizing the background and professional goals of the applicant.

Degree Requirements

A specified core curriculum includes the following courses: BCHEM 502, 505, MICRO 503, 550, 551, 552, 554, 572, and 596. To augment this core curriculum, students and their research committees will formulate an individualized supplementary curriculum choosing from advanced departmental courses in virology and immunology or from other graduate courses offered by other departments.

Student Aid

Graduate assistantships available to students in this program and other forms of student aid are described in the STUDENT AID section of the *Graduate Bulletin*.

MICROBIOLOGY (MICRO)

503. (BCHEM 503, CMBIO 503) Molecular Biology (3) Principles of molecular and microbial genetics; emphasis placed on experimental design toward problems in bacteria and lower eucaryotes. Prerequisite: BCHEM 502.

550. Medical Microbiology (2) Principles of medical microbiology: host-parasite relationships; structure and function of viruses, bacteria, and fungi as agents causing human disease.

551. Medical Microbiology (3) Principles of medical microbiology: host-parasite relationships; structure and function of viruses, bacteria, and fungi as agents causing human disease. Prerequisite: MICRO 550.

552. Medical Microbiology Laboratory (1) Laboratory exercises to augment MICRO 551. Laboratory tests used to characterize microorganisms and to aid in diagnosis of disease. Concurrent: MICRO 551.

553. Science of Virology (3) Replication of viruses and effect on host, including transfer of genetic information, immunology, and oncogenic properties of viruses.

554. Principles of Immunology (2) Study of immune response. Nature of antigens, structure, function of antibodies, hypersensitivity, transplantation and tumor immunology, autoimmunity, and immunosuppression.

555. Microbial Physiology and Metabolism (3) Physiology and comparative biochemistry of microorganisms, especially human pathogens. Regulatory mechanisms, energy metabolism, and other topics essential for cell replication.

556. Molecular Genetics (3) Structure, synthesis, and function of DNA, RNA, and proteins. Emphasis on gene structure and function in the eucaryotic cell.

557. Electron Microscopy (3) The application of electron microscopy to microbiology, including specimen preparation, use of the electron microscope, and photography. Prerequisites: admission to the medical or graduate program and permission of instructor.

558. Medical Parasitology (2) Basic information on protozoa, helminths, arthropods, and mollusks involved in the causation of human diseases.

559. Epidemiology (2) Provides information on epidemiology — the study of factors that affect occurrence and course of disease in a population.

560. (CMBIO 560) Concepts in Immunology (3) Lectures in advanced immunology, including T and B cell function, receptors, gene rearrangements, and synthetic vaccines.

572. Literature Reports (1 per semester) Weekly analysis of current literature in microbiology.

590. Colloquium (1-3)

596. Individual Studies (1-9)

597. Special Topics (1-9)

MINERAL ECONOMICS (MN EC)

RICHARD L. GORDON, *In Charge of Graduate Programs in Mineral Economics*
221 Walker Building
814-865-2549

Degrees Conferred: Ph.D., M.S.

Senior Members of the Graduate Faculty
Timothy J. Considine, Ph.D. (Cornell) *Assistant Professor of Mineral Economics*
Richard L. Gordon, Ph.D. (MIT) *Professor of Mineral Economics*
George H. K. Schenck, Ph.D. (Penn State) *Associate Professor of Mineral Economics*
William A. Vogely, Ph.D. (Princeton) *Professor of Mineral Economics*

The program in Mineral Economics prepares students in the application of economic analysis to mineral industries problems, particularly those relevant to long-term policy development by industry and government. Students may work in such areas as commodity analysis (energy, metals, or nonmetals); resource economics (mineral policy or area studies); industrial economics (administration, market research, or financial matters); geostatistical and economic analysis of exploration and exploitation problems; or operations research and statistics (resource allocation, forecasting, or decision making).

The enrollment is kept at levels that insure that students work closely on their research with the faculty and can interact regularly with each other. The training usually leads to work in industries concerned with the extraction, processing, or use of minerals; consulting firms; and government agencies. However, opportunities also exist for assuming academic positions.

Admission Requirements
Scores from the Graduate Record Examination (GRE) or the Graduate Management Achievement Test (GMAT) are required for admission. At the discretion of the program, a student may be admitted provisionally for graduate study without these scores. Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin*.

The program is designed to accommodate students with either a science and engineering or a social science background. Separate admissions requirements are maintained for the two groups. Requirements for admission for those with science or engineering backgrounds are 24 credits in chemistry, physics, mathematics, or statistics; 12 in the earth sciences; 9 in economics, mineral economics, commerce, business administration, or industrial management; and 6 in engineering subjects. Those with social science backgrounds should have 12 credits in economics, mineral economics, and business administration; 6 in geological sciences; and 9 in mathematics and statistics.

A prior master's degree is not required for admission to the Ph.D. program. Students with deficiencies of 9 credits or fewer in either progam may be admitted as degree candidates but will be required to make up such deficiencies without these credits being applicable toward the advanced degree. Admission is largely determined on the basis of achievement of a junior-senior grade-point average of 3.00 or better, above average scores on the GRE or GMAT, and appropriate prior course work. Students meeting these requirements can receive admission so long as space is available. Admission is normally for the fall semester.

Degree Requirements

The core courses in mineral economics, economics, statistics, and other related fields are similar for all graduate students. At the M.S. level, the core courses constitute almost the entire program, and students without sufficient prior work find that they must earn 35 to 40 credits to meet these requirements. In addition to the normal degree requirements of the Graduate School, candidates for the M.S. degree must write a thesis or professional paper and defend it orally. Differences in prior training are most influential on the choice of thesis or professional paper topics. Those with an engineering or scientific background are more likely to undertake studies involving substantial technological elements while issues in the social sciences will be stressed by those with training in that area. M.S. students are required to take 9 to 12 credits in statistics and computer science either before admission or as courses taken in addition to the minimum required for the M.S. degree.

The Ph.D. program offers opportunities for students to extend work in either the technical or economic area. For those students who have a master's in a related area, their prior graduate work is considered to fulfill the requirement for work in related fields, and further work consists mainly of satisfying specific course requirements. Again, the backgrounds from prior work and what is done at Penn State will affect the orientation of the theses undertaken. Doctoral candidates must complete at least 15 credits in economics (including courses used for admission).

The candidacy examination for the doctorate is oral, and the oral examination for the M.S. degree at Penn State may be used as the candidacy examination for the doctorate. If this is done, the M.S. examination will be more detailed and broader in scope than it would be for the M.S. alone. The comprehensive examination for the doctorate includes written examinations in the major program and minor fields in addition to the oral examination required by the Graduate School. The communication requirement is satisfied by departmentally approved courses in mathematical statistics and mathematics. There is no foreign language requirement.

Other Relevant Information

Students in this program may elect the dual-title program in Operations Research for the Ph.D. and M.S. degrees (see p. 326).

Student Aid

Graduate assistantships available to students in this program and other forms of student aid are described in the STUDENT AID section of the *Graduate Bulletin*.

MINERAL ECONOMICS (MN EC)

453. Nonmetallic Minerals (3)
483. Economics of the Metals Industries (3)
484. Political Economy of Energy and the Environment (3)
490. Mineral Valuation (3)
491. Mineral Policy Analysis (3)
495. Internship (1-18)
496. Independent Studies (1-18)
497. Special Topics (1-9)
499. Foreign Study — Mineral Industries (1-12)

504. Advanced Principles of Mineral Economics (3) Minerals as capital — taxation, conservation, and land tenure; operations of mineral markets; government policy; minerals in world trade and development.

506. Advanced Studies in Mineral Commodities (3) Economic studies of selected mineral commodities and their products.

509. (GEOL 509) Geology and Economics of the Construction Materials (3) Occurrence, origin, and marketing of the mineral materials used by the construction industry. Economic and geologic evaluation of actual deposits.

510. (GEOL 510) Geology and Economics of the Industrial Minerals (3) Occurrence, origin, and marketing of the industrial minerals and evaluation of deposits. Chemical and ceramic raw materials emphasized.

513. Appraisal of Mineral Resources and Analysis of Exploration Decisions (3) Mineral resource concepts; various quantitative methods for resource evaluation, including computer simulation; exploration economics and decision making within quantitative frameworks. Prerequisite: MN EC 490.

519. Mineral Policy Analysis (3) Principles of policy analysis; cost-benefit and other analytical techniques; environmental analyses; case studies of legislative and administrative mineral policy issues.

523. Economic Analysis of Metal Industries (3) Economic analysis of metal supply, demand, markets, industry conduct and performance, trade, domestic and foreign policies. Prerequisite: ECON 302.

524. The Economic Analysis of Energy Markets (3) Unified theory of exploration, development, and production; its application; domestic and foreign public policies; new sources; forecasting. Prerequisite: ECON 302.

529. Mineral Investment Valuation (3) Investment analysis for mineral properties, including reserve estimation, capital budgeting techniques under risk, taxation, capital cost, and selected investment decisions.

590. Colloquium (1-3)

596. Individual Studies (1-9)

597. Special Topics (1-9)

602. Supervised Experience in College Teaching (1-3 per semester, maximum of 6)

MINERAL ENGINEERING MANAGEMENT (M E M)

R. V. RAMANI, *Section Chair of Mineral Engineering Management*
104 Mineral Sciences Building
814-863-1621

Degree Conferred: M.Eng.

Senior Members of the Graduate Faculty
Frank F. Aplan, Sc.D. (MIT) *Professor of Metallurgy and Mineral Processing*
Z. T. Bieniawski, Ph.D. (S. Africa) *Professor of Mineral Engineering*
Turgay Ertekin, Ph.D. (Penn State) *Professor of Petroleum and Natural Gas Engineering*
William L. Ferrara, Ph.D. (Michigan State) *Professor of Accounting*
Robert L. Frantz, M.S. (Penn State) *Professor of Mining Engineering*
Peter H. Given, D.Phil. (Oxford) *Professor of Fuel Science*
Peter T. Luckie, Ph.D. (Penn State) *Professor of Mineral Processing*
Jan M. Mutmansky, Ph.D. (Penn State) *Associate Professor of Mineral Engineering*
David L. Passmore, Ph.D. (Minnesota) *Associate Professor of Vocational Education*
Raja V. Ramani, Ph.D. (Penn State), P.E. *Professor of Mining Engineering*
Matthew Rosenshine, Ph.D. (SUNY-Buffalo) *Professor of Industrial Engineering*
George H. K. Schenck, Ph.D. (Penn State) *Associate Professor of Mineral Economics*
Allen L. Soyster, Ph.D. (Carnegie-Mellon) *Professor of Industrial Engineering*
Gerald I. Susman, Ph.D. (UCLA) *Professor of Organizational Behavior*
William A. Vogely, Ph.D. (Princeton) *Professor of Mineral Economics*
Harry H. West, Ph.D. (Illinois), P.E. *Associate Professor of Civil Engineering*
Jack H. Willenbrock, Ph.D. (Penn State), P.E. *Professor of Civil Engineering*

Associate Members of the Graduate Faculty
Michael Adewumi, Ph.D. (Illinois) *Assistant Professor of Petroleum and Natural Gas Engineering*
Christopher J. Bise, Ph.D. (Penn State) *Associate Professor of Mining Engineering*
M. Jeya Chandra, Ph.D. (Syracuse) *Assistant Professor of Industrial Engineering*
Jeffery L. Kohler, Ph.D. (Penn State) *Assistant Professor of Mining Engineering*
Lee B. Phelps, Ph.D. (Penn State) *Associate Professor of Mining Engineering*

This program is designed to educate engineers for advancement into executive production management positions in the mineral and heavy construction industries, in development and sales in manufacturing companies, and in consulting firms. Its aim is to provide the knowledge, skills, and attitudes needed by persons to become innovators and responsible decision-making leaders. Participants are trained to create new designs, systems, and methods, and to plan, develop, and lead mineral industry organizations.

The content of appropriate courses is based upon specific problems encountered in the mineral industries. Such courses are offered by the departments that have combined their resources to offer this interdisciplinary effort: the Departments of Mineral Engineering (Mining and Petroleum and Natural Gas sections), Mineral Economics, Materials Science and Engineering, and Industrial and Management Systems Engineering. Courses in these areas and others may be selected by students and adapted to their individual interests.

The program emphasizes quantitative methods, principles of economics applied in mineral industries, and management.

Admission Requirements

Scores from the Graduate Record Examination (GRE) are not required for admission. Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin*.

For admission a bachelor's degree in one of six engineering branches of mineral industry (mining, petroleum, mineral processing, metallurgy, fuel, or ceramics) or some other closely related field (industrial, civil, geological, mechanical, or chemical engineering) is required. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

Degree Requirements

Students are required to present a scholarly written report on a suitable project, the topic of which may be suggested by industry. The report must be approved by a committee of the faculty comprised of the report adviser, report reader, and the chair of the program. Each student also is required to take 1 credit of colloquium and present a satisfactory seminar on some topic, including the report topic.

Student Aid

Graduate assistantships available to students in this program and other forms of student aid are described in the STUDENT AID section of the *Graduate Bulletin*.

MINERAL ENGINEERING MANAGEMENT (M E M)

510. Production and Operations Management (3-9) Overall planning, design, and selection of equipment; programming and scheduling of mineral operations; statistical control of costs and production indices.

MINERAL PROCESSING (MN PR)

RICHARD HOGG, *In Charge of Graduate Programs in Mineral Processing*
108 Steidle Building
814-863-0373

Degrees Conferred: Ph.D., M.S.

Senior Members of the Graduate Faculty

Frank F. Aplan, Sc.D. (MIT) *Professor of Metallurgy and Mineral Processing*
Leonard G. Austin, Ph.D. (Penn State) *Professor of Fuels and Mineral Engineering*
Richard Hogg, Ph.D. (California-Berkeley) *Professor of Mineral Processing*
Peter T. Luckie, Ph.D. (Penn State) *Professor of Mineral Engineering*
K. Osseo-Asare, Ph.D. (California-Berkeley) *Associate Professor of Metallurgy*

Associate Members of the Graduate Faculty

S. Chander, Ph.D. (California-Berkeley) *Associate Professor of Mineral Processing*
Richard R. Klimpel, Ph.D. (Penn State) *Adjunct Professor of Mineral Processing*

This program is one of the options in which a graduate student in the Department of Mineral Engineering can receive an advanced degree. After ores and minerals are mined, they are usually processed to concentrate valuable components or remove undesirable components, and then they are

converted into useful products. The world is facing shortages of energy, water, and raw materials, and the mineral processing engineering profession will play a key role in reducing and solving these problems. Increased efficiency and new ideas are urgently needed.

The training of a mineral processing engineer involves interdisciplinary combinations of chemistry, physics, the geological sciences, and engineering. This knowledge is then integrated with specialized knowledge — the creation, characterization, separation, agglomeration, and handling of mineral particles; the flotation and surface chemistry of mineral particles; and chemical extractions and separations — to provide the basis for developing and understanding the practical means of removal of valuable material from the rock body.

Pollution control is an important aspect of mineral processing because of the problems of disposal of large quantities of waste produced by the mineral industries, and the volume of process water used by the industries. The section cooperates in the all-University interdisciplinary program leading to the Master of Science in environmental pollution control or the Master of Environmental Pollution Control.

Admission Requirements

Scores from the Graduate Record Examination (GRE), or from a comparable substitute examination accepted by the graduate program, are required for admission. Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin*.

Graduates with bachelor's degrees in an engineering or science discipline are normally eligible for admission. Students with deficiencies may be required to take a modest amount of remedial work concurrently with their graduate studies. Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds (such as industrial experience), abilities, and interests.

Master's Degree Requirements

Students will be expected to demonstrate competence in areas outside of the major field and may be required to take courses in other fields. A research thesis is required of all M.S. students and must be defended orally before a committee of the faculty. Every student also will be expected to present a satisfactory seminar on the results of his or her research.

Doctoral Degree Requirements

The communication and foreign language requirement for the Ph.D. degree may be satisfied by reading proficiency in one foreign language. Students whose first language is English must demonstrate proficiency in German, Russian, or Japanese (or other language in which a major body of relevant technical literature exists). Students whose first language is not English will be required to show fluency in reading, speaking, comprehending, and writing English and may in some cases be required to demonstrate proficiency in one other approved language.

No set number of credits is required, but a student normally would be expected to take a minimum of 15 credits of course work beyond the M.S. degree. Ph.D. candidates will be expected to demonstrate competence in the areas of (1) general mineral processing, (2) applied surface chemistry, (3) particle technology, (4) chemical processes, process metallurgy, and thermodynamics.

A minor field is not required. However, Ph.D. candidates will be expected to take at least 12 credits outside of the major. These courses need not be in a single field but should consist of a coherent group with some unifying theme.

Admission to candidacy is by examination (written and/or oral) and normally includes a satisfactory written paper consisting of a definition of the student's research problem and a critical evaluation of the relevant literature or a coherent critical review of the literature on some appropriate topic. In some cases, the Penn State M.S. thesis defense in mineral processing may be used to satisfy some or all of these requirements.

The comprehensive examination consists of two parts: (1) a written examination to test the candidate's factual knowledge of the general areas of mineral processing and his or her ability to synthesize this knowledge in the solution of problems; and (2) an oral examination by the doctoral committee including a presentation, by the candidate, of his or her research problem, relevant literature, data, and future plans. The committee will then examine the candidate concerning the research problem and background knowledge until they are satisfied they can make a decision.

Other Relevant Information
A study panel of three faculty members, including the research adviser, is established for each student. The student and his or her research adviser prepare a proposed program of study, which is discussed and approved at a meeting of the student and the study panel. The student and study panel meet at suitable intervals to review progress and modify the program if necessary.

Student Aid
Graduate assistantships available through this program and other forms of student aid are described in the STUDENT AID section of the *Graduate Bulletin*. Graduate assistantships in Mineral Processing are generally for research and are usually available to qualified students.

MINERAL PROCESSING (MN PR)

401. Mineral Process Engineering (3)
410. Introduction to Quantitative Mineral Processing Engineering Analysis (3)
413. Mineral Processing Laboratory (1)
421. Particle Technology Laboratory (1-3)
424. Coal Preparation (3)
425. Interfacial Phenomena and Flotation (3)
426. (METAL 426) Aqueous Processing (3)
427. Pollution Control in the Mineral Process Industries (3)
451. Senior Projects (1-6)

501. Interfacial Phenomena in Mineral Systems (3) Applications of surface phenomena to mineral engineering systems. Thermodynamics of surfaces, flotation, adsorption of detergents, electrical double layer, flocculation, dispersion. Prerequisite: CHEM 451.

502. Froth Flotation and Agglomeration (3) Intensive study of theory and applications of froth flotation and agglomeration. Prerequisite: MN PR 501.

503. Colloid Phenomena (3) Flotation microkinetics; shear, carrier, and selective flocculation; aerosols, foams, and emulsions; spherical agglomeration and emulsion flotation; colloids in hydrometallurgy. Prerequisite: CHEM 451.

505. Physical Separations in Mineral Processing (3) Intensive study of theory and applications of gravity, magnetic, electrostatic, centrifugal, and other methods of mineral processing. Prerequisite: MN PR 401.

506. Mineral Process Plant Design (3-10) Process design and economy. Development and quantification of flow sheets. Integration of unit operations. Plant layout, equipment selection, and instrumentation. Prerequisite: MN PR 401.

507. (METAL 507) Hydrometallurgical Processing (3) Fundamental physico-chemical factors underlying the aqueous extraction and recovery of metals and nonmetals from ores, minerals, and scrap metal. Prerequisite: MN PR (METAL) 426.

508. Mineral Particle Systems (3) Creation, characterization, separation, and agglomeration of particles. Comminution, sizing, fractionation of powders; surface area, pore size determinations. Agglomeration and balling.

509. Particle-Fluid Dynamics (3) Movement of particles in fluids, rheology of non-Newtonian mineral suspensions, design of concentrating devices, fluidized beds, electrodynamic, magnetic separations.

510. Size Reduction (3) Review of the state of the art in precise design of size reduction devices; their incorporation into mineral processing circuits.

520. Mathematical Modeling for Mineral Process Engineers (3) Techniques for setting up mathematical models of physical processes of interest in mineral process engineering; analytical and computational methods of solution. Prerequisite: MATH 250.

590. Colloquium (1-3)

596. Individual Studies (1-9)

597. Special Topics (1-9)

602. Supervised Experience in College Teaching (1-3 per semester, maximum of 6)

MINING ENGINEERING (MNG E)

JAN M. MUTMANSKY, *Acting Section Chair of Mining Engineering*
120 Mineral Sciences Building
814-863-1642

DEREK ELSWORTHY, *Graduate Program Officer*
119 Mineral Sciences Building
814-863-1643

Degrees Conferred: Ph.D., M.S., M.Eng.

Senior Members of the Graduate Faculty
Z. T. Bieniawski, D.Sc. (Eng.) (Pretoria) *Professor of Mineral Engineering*
Robert L. Frantz, M.S. (Penn State) *Professor of Mining Engineering*
H. Reginald Hardy, Jr., Ph.D. (Virginia Polytechnic) *Professor of Mining Engineering*
Jan M. Mutmansky, Ph.D. (Penn State) *Associate Professor of Mining Engineering*
Raja V. Ramani, Ph.D. (Penn State) *Professor of Mining Engineering*
Barry Voight, Ph.D. (Columbia) *Professor of Geology*

Associate Members of the Graduate Faculty
Eric K. Albert, Ph.D. (Penn State) *Assistant Professor of Mining Engineering*
Christopher J. Bise, Ph.D. (Penn State) *Associate Professor of Mining Engineering*
Derek Elsworth, Ph.D. (California-Berkeley) *Assistant Professor of Mining Engineering*
Jeffery L. Kohler, Ph.D. (Penn State) *Assistant Professor of Mining Engineering*
L. Barry Phelps, Ph.D. (Penn State) *Associate Professor of Mining Engineering*

Mining Engineering is one of the graduate programs within the Department of Mineral Engineering. The program objectives are to train students in the methodology of research and to expand the student's knowledge in selected subjects related to research as well as to the entire field of mining engineering.

Areas of specialization in research and course work include computer applications, environmental control, geomechanics and rock mechanics, health and safety, innovative mining systems, materials handling, mine electrical systems, mine maintenance, mine management, mine planning and reclamation, monitoring and control, operations research, surface mining, underground mining, and ventilation. Interests cover coal, metal, and nonmetal mining.

The program has outstanding facilities for mining engineering research. Among these are the C. B. Manula Computer Laboratory, the Mine Electrical Research Laboratory, the Rock Mechanics Laboratory, and the Ventilation Laboratory.

Admission Requirements

Scores from the Graduate Record Examination (GRE) are required for admission. At the discretion of a graduate program, a student may be admitted provisionally for graduate study in the program without these scores. Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin*.

A bachelor's degree in mining engineering or a related engineering field is required for admission at the master's level. Students may be required to make up deficiencies in basic related courses outside the department or in their area of specialization. Applicants with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds (such as industrial experience), abilities, and interests.

A master's degree in mining engineering or its equivalent is required for admission into the doctoral program. A copy of the student's master's thesis may be required as part of the application materials. A candidacy examination is required of all potential candidates.

Master's Degree Requirements

A student who wants to obtain the M.S. degree is required to prepare a thesis. The thesis must be scholarly, reporting research of a contribution to the discipline, and it must be defended orally in front of an advisory committee of graduate faculty members.

A student who wants to obtain the M.Eng. degree is required to prepare a written report. The report must be a scholarly achievement, relating a developmental study that involves an appropriate, significant subject in the discipline.

Doctoral Degree Requirements

The Ph.D. degree requires a minimum of 90 graduate credits, and up to 30 credits may be allowed for a previously obtained master's degree. A minimum of 60 course credits (400 and 500 series) and 30 research credits (MNG 600) must be part of the program. At least 2 credits of MNG 590 (Colloquium) also are needed during the period of candidacy.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by obtaining suitable credit either in two foreign languages or one foreign language plus advanced computer science studies. Foreign languages normally must be French, German, Russian, or Spanish, but in special circumstances, other languages may be accepted. Passing requirements are either a passing grade in ETS (Princeton) examinations or a minimum grade of B in associated 1G and 2G courses. Computer science studies are satisfied by obtaining a minimum grade of B in 6 credits of computer science above the undergraduate mining requirements. Courses taken to satisfy the communication and language requirements cannot be considered as part of the Ph.D. course requirements.

A comprehensive examination is required of all Ph.D. candidates and may be taken after substantial completion of course work and completion of the language requirements. The examination is the responsibility of the candidate's doctoral committee and takes the form of a written examination, which if successful, is followed by an oral examination as specified by the Graduate School.

A thesis is required of all Ph.D. candidates. It must be scholarly, reporting original research of significant contribution to the discipline. The ability to do independent research and competence in scholarly exposition must be demonstrated. The thesis must be defended in a final oral examination that is officially scheduled and announced by the Graduate School.

Other Relevant Information

Continuous registration is required of all graduate students until the thesis or engineering report is approved.

Students in this program may elect the dual-title degree program option in Operations Research for the Ph.D. and M.S. degrees (see p. 326).

Student Aid

In addition to the fellowships, traineeships, graduate assistantships, and other forms of financial aid described in the STUDENT AID section of the *Graduate Bulletin*, the following awards typically have been available to graduate students in this program:

Conoco Coal Research Division Fellowship — Available to a graduate student who is a U.S. citizen or has a permanent visa and who is interested in research that will benefit the coal industry; stipend $6,000 per year; fellowship awarded on a year-to-year basis at the discretion of the provider.

Consolidation Coal Company Fellowship — Available to an outstanding Ph.D. candidate in mining engineering who is a U.S. citizen and who is interested in pursuing a career in college teaching; stipend $13,000 per year plus tuition; fellowship awarded on a year-to-year basis at the discretion of the provider.

Mining and Mineral Resources Research Fellowships — Available to graduate students majoring in mining and mineral sciences and pursuing M.S. and Ph.D. degrees; stipend $6,240-$7,100 for four semesters plus tuition.

Texaco Fellowship in Earth and Mineral Sciences — Available to a graduate student in the College of Earth and Mineral Sciences; stipend $1,200-$3,000 plus tuition.

MINING (MNG)

400. Mining and Our Environment (3)
402. Mine Plant Engineering (2)
403. Mine Power System Design (3)
404. Mine Materials Handling Systems (2)
405. Mine Power System Maintenance and Hazard Reduction (3)
406. Mine Monitoring (3)
410. Mining Engineering Analysis (3)
411. Mine Systems Engineering (2)
412. Exploration and Ore Estimation (2)
422. Mine Ventilation and Air Conditioning (3)
431. Rock Mechanics Laboratory and Field Techniques (2)

441. Surface Mining Systems and Design (2)
442. Surface Mine Sedimentation Control (2)
443. Strip Mine Cut Planning (2)
444. Groundwater Aspects in Mining (1)
451W. Mining Engineering Project (1-3)
460. Mine Maintenance Engineering (3)

502. Mine Power System Protection (3) Protective circuitry, coordination, transient protection, and hazard reduction applied to mine power systems. Prerequisite: MNG 403 or E E 425.

503. Mine Power Equipment and Grounding (3) Advanced analysis and design of mine power equipment, protective-relaying systems, and grounding systems. Prerequisites: MNG 502, E E 425.

510. Advanced Mining Systems (3) Mining of thick, thin, or pitching seams; multiseam and in-situ mining; health and safety considerations. Prerequisite: MNG 410.

513. Mine Cost Analysis (3) Nature of mining costs, their analysis and control: depreciation and depletion, capital and operating costs, budgets, records.

514. Mine Operations Analysis (3) Application of operations research techniques in determining optimal design and operating policies for mine management. Prerequisite: MNG 411.

515. Mine Systems Simulation (3) Principles and practices of probabilistic and deterministic simulation in the analysis of operating systems related to mills and mines. Prerequisites: CMPSC 201, MNG 411.

516. Mining Geostatistics (3) Applicaion of classical and spatial statistics in the study of mine exploration, ore reserve estimation, mining grade control, mine planning, and mine ventilation. Prerequisite: 3 credits of statistics at the 400 level.

531. Rheological and Strength Characteristics of Rocks (3) Properties of rocks and their determination; failure theories; brittle to ductile transition; rheological behavior. Prerequisite: MNG 431.

541. Surface Mine Equipment Selection Analysis (3) Design analysis and selection criteria for principal surface mine equipment, their interaction in operation, and auxiliary equipment requirements. Prerequisite: MNG 441, C E 261.

542. Theory of Rock Fragmentation (3) Behavior of rock under dynamic loads intended to fragment; physical chemistry of explosives; detonation; theory of blasting; design of drill rounds. Prerequisites: E MCH 013, MNG 030, PHYS 203.

543. Strata Control Engineering (3) Theoretical considerations; convergence, abutments, subsidence; rockbursts; underground support systems; design of mine openings. Prerequisite: MNG 431.

545. Rock Mechanics Instrumentation (3) Strain gauge circuitry, transducers, electrohydraulic servo installations, and integrated strain and force measuring systems as applied to rock mechanics. Prerequisite: MNG 431.

551. Theory of Rock Failure (3) Mechanism of rock failure, factors of influence, theories of failure, fracture toughness, fracture propagation, time dependency, implications in engineering practice. Prerequisite: MNG 431.

552. Geomechanics Aspects of Tunneling in Rock (3) Use of tunnels; site exploration; rock mass classification; tunnel design: analytical, observational, empirical; tunnel excavation and support; large, underground chambers. Prerequisite: MNG 431 or C E 446.

553. Rock Slope Engineering (3) Mechanics of slope failure; geological data collection; shear strength of rock; groundwater flow; design of rock slopes, reinforcement, and monitoring. Prerequisite: MNG 431.

554. Rock Mechanics Design (3) Engineering design process; design of mines, tunnels, slopes, and underground chambers; guided design concept; creativity and innovation; group design project. Prerequisite: MNG 543.

557. Computational Geomechanics I (3) Finite element and boundary element analysis of rock mechanics, groundwater flow, and mass transport.

590. Colloquium (1-3)

596. Individual Studies (1-9)

597. Special Topics (1-9)

MOLECULAR AND CELL BIOLOGY (M C B)

W. D. TAYLOR, *In Charge of Graduate Programs in Molecular and Cell Biology*
106 Althouse Laboratory
814-865-1968

Degrees Conferred: Ph.D., M.S.

Senior Members of the Graduate Faculty
Nathan N. Aronson, Jr., Ph.D. (Duke) *Professor of Biochemistry*
Donald A. Bryant, Ph.D. (UCLA) *Associate Professor of Molecular and Cell Biology*
Reginald A. Deering, Ph.D. (Yale) *Professor of Molecular and Cell Biology*
Richard J. Frisque, Ph.D. (Wisconsin) *Associate Professor of Microbiology*
Ross C. Hardison, Ph.D. (Iowa) *Associate Professor of Microbiology*
Kenneth A. Johnson, Ph.D. (Wisconsin) *Paul Berg Professor of Biochemistry*
Alec D. Keith, Ph.D. (Oregon) *Adjunct Professor of Biophysics*
Richard S. Morgan, M.D. (Columbia) *Adjunct Associate Professor of Biophysics*
Stanley R. Person, Ph.D. (Yale) *Professor of Biophysics and Molecular Biology*
Ronald D. Porter, Ph.D. (Duke) *Associate Professor of Microbiology and Molecular Genetics*
Robert A. Schlegel, Ph.D. (Harvard) *Associate Professor of Molecular and Cell Biology*
David I. Shalloway, Ph.D. (MIT) *Associate Professor of Molecular Biology*
Thomas Smyth, Jr., Ph.D. (Johns Hopkins) *Professor of Entomology and Biophysics*
Wallace Snipes, Ph.D. (Duke) *Professor of Biophysics*
S. Edward Stevens, Jr., Ph.D. (Texas) *Associate Professor of Microbiology and Molecular Biology*
William D. Taylor, Ph.D. (Manchester) *Professor of Biophysics*
Chen-Pei David Tu, Ph.D. (Cornell) *Associate Professor of Biochemistry and Molecular Biology*

Associate Members of the Graduate Faculty
Teh-Hui Kao, Ph.D. (Yale) *Assistant Professor of Molecular and Cell Biology*
B. Tracy Nixon, Ph.D. (MIT) *Assistant Professor of Molecular and Cell Biology*
Don M. Wojchowski, Ph.D. (Massachusetts) *Assistant Professor of Molecular and Cell Biology*

The major goal of this program is to train students for independent research and teaching in molecular and cell biology and related fields. Students may enter the program from a variety of backgrounds such as biochemistry, biology, biophysics, cell biology, chemistry, genetics, microbiology, molecular biology, physics, premedicine, or others. The student's research starts during the first year. Research areas of faculty include biological membranes, calcification, cell fusion, chemical mutagenesis and carcinogenesis, DNA repair, flow cytofluorimetry, gene regulation, glycoprotein metabolism, electrophysiology, lysosome function, macromolecular assembly, molecular genetics, radiation biology, recombinant DNA, virology, and others.

Admission Requirements
Scores from the Graduate Record Examination (GRE) Aptitude Test (verbal, quantitative, and analytical) are normally required for admission. Only under exceptional circumstances will an application be considered without these scores. Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin*.

Admission to the program is based on prior course record and grades, GRE scores, letters of recommendation, and interviews.

Virtually all students are admitted with the intent of obtaining a Ph.D. degree. Although the master's is usually obtained on the way to the Ph.D., this degree may be bypassed in some cases.

Master's Degree Requirements

There are no M.S. degree requirements beyond those specified by the Graduate School. The master's program is expected to take about two years.

Doctoral Degree Requirements

Advancement to Ph.D. candidacy is decided on the basis of course and research performance in addition to a written examination. A comprehensive oral examination and thesis defense are required later in the Ph.D. program. The Ph.D. takes about two to three years beyond the M.S.

Other Relevant Information

Beginning students participate in a core curriculum of course work in common with students in the biochemistry and microbiology graduate programs and in rotations through research projects in two or three faculty laboratories before deciding on a research area.

Further course work and research are individually planned by the student and the adviser, in consultation with other faculty, to achieve consistency with the background, requirements, and interests of the student.

Research and instruction in aspects of molecular and cell biology also are conducted in several other graduate programs at University Park and at The Milton S. Hershey College of Medicine.

Student Aid

Graduate assistantships available to students in this program and other forms of student aid are described in the STUDENT AID section of the *Graduate Bulletin*.

Under normal circumstances all students admitted to the program and continuing in good standing are provided with graduate assistantship support from University sources and research grants.

MOLECULAR AND CELL BIOLOGY (M C B)

435. (MICRB 435) Medical Virology (2)
440. Structure and Function of Biological Membranes (2)
450. (MICRB 450) Microbial/Molecular Genetics (2)
460. (MICRB 460) Advanced Cell Biology (2)
474. Physical Properties of Biological Macromolecules (2)
475. Mutagenesis, Carcinogenesis, and DNA Repair (2)
476. Neurophysiology (3)
480. (MICRB 480) Tumor Virology (3)
496. Independent Studies (1-18)
497. Special Topics (1-9)

504. (BIOL 504) Seminar in Cell Biology (1) Discussion of current problems and ideas in cell biology, with emphasis on reference to recent literature.

505. (MICRB 505) Microbial Genetics (2 per semester, maximum of 4) Modern concepts in the genetics of microorganisms. Prerequisite: M C B (MICRB) 450.

510. Current Literature in Molecular Biology (1) Discussion and analysis of recent scientific papers that form the core of current literature in molecular biology.

514. (BIOCH 514) Molecular Biology and Cellular Regulation (3) Structure, synthesis, and biochemical properties of nucleic acids; protein biosynthesis; control of gene expression; molecular genetics. Prerequisite: BIOCH 402.

560. Molecular Basis of Mutagenesis and Carcinogenesis (3) Action of physical and chemical environmental agents on genetic material; DNA repair; mutagenic and carcinogenic consequences. Prerequisite: M C B 430.

589. Mammalian Cell Culture (3) Recent research in quantitative cell biology as studied with tissues and cells of higher organisms cultured *in vitro*. Prerequisite: BIOCH 401.

590. Colloquium (1-3)

597. Special Topics (1-9)

602. Supervised Experience in College Teaching (1-3 per semester, maximum of 6)

MUSIC (MUSIC and MU ED)

LYLE C. MERRIMAN, *Director, School of Music*
233 Music Building
814-865-0431

Degrees Conferred: D.Ed., M.A., M.Mus., M.Ed.

Senior Members of the Graduate Faculty
Maureen A. Carr, Ph.D. (Wisconsin) *Professor of Music*
Ned C. Deihl, D.Ed. (Penn State) *Professor of Music Education*
Burt L. Fenner, M.A. (Columbia) *Professor of Music*
Bryce Jordan, Ph.D. (North Carolina) *Professor of Musicology*
Lyle C. Merriman, Ph.D. (Iowa) *Professor of Music*
D. Douglas Miller, D.Mus. (Indiana) *Associate Professor of Music*
James Moeser, D.M.A. (Michigan) *Professor of Music*

Associate Members of the Graduate Faculty
Daniel Armstrong, M.Mus. (Michigan) *Assistant Professor of Music*
Joanne M. Feldman, M.S. (Juilliard) *Associate Professor of Music*
Leonard Feldman, M.Mus. (Eastman) *Associate Professor of Music*
Donald E. Hopkins, M.Mus. (Texas) *Associate Professor of Music*
Mark Lusk, M.Mus. (Eastman) *Assistant Professor of Music*
P. June Miller, M.Mus. (Yale) *Associate Professor of Music*
M. Suzanne Roy, D.M.A. (Wisconsin) *Associate Professor of Music*
Joanne Rutkowski (SUNY-Buffalo) *Assistant Professor of Music Education*
Steven H. Smith, D.Mus.A. (Eastman) *Professor of Music*
Brian Stewart, Ph.D. (Stanford) *Assistant Professor of Music*
Smith C. Toulson III, M.Mus. (Yale) *Associate Professor of Music*
W. Bruce Trinkley, M.A. (Columbia) *Associate Professor of Music*
M. Daniel Yoder, M.M. (Idaho) *Assistant Professor of Music*

Admission Requirements
Scores from the Graduate Record Examination (GRE) aptitude test and the advanced test in music are required for admission to the M.A. program. Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin*.

Admission to the graduate program in Music requires the completion of a recognized baccalaureate degree in music or music education, with a junior-senior average of 2.80 or above, and is contingent upon departmental certification of the candidate's competence. Students who lack the recommended upper-class undergraduate courses may be required to take additional course work without receiving credit toward their degree.

For admission to the M.Mus. program, an audition or the submission of manuscripts (according to the area of specialization) is required. Information regarding specific audition requirements and the scheduling of auditions can be obtained from the School of Music office.

Degree Requirements
The Master of Arts degree (30 credits) is directed toward musicological research. A thesis is required. A reading knowledge of German must be demonstrated before registering for thesis credit.

The Master of Education (30 credits) may include emphasis in various areas such as public-school music teaching, music supervision, college teaching, administration, or research. A master's paper is required.

The Master of Music (36 credits) provides three options for emphasis: performance, composition, and conducting. Depending on the option, a recital, a composition project, or a conducting project is required. In addition, a master's paper or a lecture-recital is required for all M.Mus. candidates.

In all master's programs at least one-half of the required credits must be at the 500 level, and a comprehensive examination is required.

Doctoral Degree Requirements
The Doctor of Education in Music Education (90 credits beyond the baccalaureate degree) is designed to prepare teachers and researchers for positions in institutions of higher education, as well as positions of leadership in large city systems and state departments of education. A candidacy examination is required, as are a doctoral thesis and comprehensive written and oral examinations.

Other Relevant Information

The School of Music sponsors many musical ensembles, and candidates for degrees are required to participate in positions of responsibility. All candidates for degrees are expected to be in residence for a minimum of two semesters.

The School of Music is an accredited institutional member of the National Association of Schools of Music.

Student Aid

Graduate assistantships available to students in this program and other forms of student aid are described in the STUDENT AID section of the *Graduate Bulletin*.

MUSIC (MUSIC)

Individualized instruction is offered in six categories covering nineteen instruments:

Brass (Brass)	Trumpet, French horn, trombone, euphonium, tuba
Keyboard (Keybd)	Piano, organ, harpsichord
Strings (Strng)	Violin, viola, violoncello, double bass
Woodwinds (Wwnds)	Flute, oboe, clarinet, bassoon, saxophone
Percussion (Percn)	
Voice (Voice)	

Instruction is offered for each instrument in three different modes: Secondary for 1 credit, Secondary for 2 credits, and Performance for 4 credits.

The Performance mode is available only to M.Mus. (Performance) students in their major area. All other students take Secondary for 1 or 2 credits.

Applied music fees are required for individual instruction: $60 for a 1-credit course, $100 for a 2-credit course, and $100 for a 4-credit course.

Example of listings:

Course Abbreviation	Number & Suffix	Instrument	Mode	Credit	Fee
KEYBD	500J	Piano	Secondary	1	$ 60
KEYBD	510J	Piano	Secondary	2	100
KEYBD	530J	Piano	Performance	4	100
KEYBD	501J	Organ	Secondary	1	60
KEYBD	511J	Organ	Secondary	2	100
KEYBD	531J	Organ	Performance	4	100
KEYBD	502J	Harpsichord	Secondary	1	60
KEYBD	512J	Harpsichord	Secondary	2	100
KEYBD	532J	Harpsichord	Performance	4	100

A complete listing can be obtained from the School of Music office.

405. Musica Da Camera (1 per semester, maximum of 4)
417. Percussion Pedagogy (2)
418. Vocal Pedagogy (3)
419. Piano Pedagogy (3)
420. Vocal Accompanying Techniques (2 per semester, maximum of 4)
421. Keyboard Musicianship (2)
422. Jazz Harmony and Arranging (3)
431. Advanced Analysis I (2)
432. Advanced Analysis II (2)
442. Advanced General Music Methods (2)
443. Advanced Choral Methods (2)
444. Advanced Instrumental Methods (2)
446. Student Teaching — Elementary General Music (6-8)
447. Student Teaching — Secondary General Music (6-8)
448. Student Teaching — Secondary Choral Music (6-8)
449. Student Teaching — Instrumental Music (6-8)
450. Teaching Marching Band (3)
457. Composition (3 per semester, maximum of 18)
458. Electronic Music (3)

461. Music of the Middle Ages and Early Renaissance (4)
462. Music of the Late Renaissance and Baroque Eras (4)
463. Music of the Classical and Early Romantic Periods (4)
464. Late Romantic and Modern Music (4)
466. Advanced Conducting (2)
467. Opera Workshop (1-3 per semester, maximum of 6)
471. Structural and Sixteenth-Century Counterpoint (2)
472. Eighteenth-Century Counterpoint (2)
476. B.A. Senior Project (3)
478. Vocal Literature I (2)
479. Vocal Literature II (2)
481. Keyboard Literature I (2)
482. Keyboard Literature II (2)
483. Percussion Literature (3)
484. Guitar Literature (2)
485. Chamber Music Literature (2)
486. Woodwind Literature (2 per semester, maximum of 4)
487. Orchestral Literature (2 per semester, maximum of 4)
489. Studio and Recital Accompaniment (1 per semester, maximum of 4)
490. Chamber Music for Strings (1 per semester, maximum of 4)
491. Chamber Music for Woodwinds (1 per semester, maximum of 4)
492. Chamber Music for Brass (1 per semester, maximum of 4)
493. Sonata Duos (1 per semester, maximum of 4)
494. Research Topics (1-3)
496. Independent Studies (1-18)
497. Special Topics (1-9)

500. Introduction to Music Reference and Research Materials (2) A study of musicological reference and research materials in English and Western European languages, with exercises in their use.

531. Analytical Techniques (3) Intensive analytical study of selected compositions.

535. Free Composition (4) Composition for vocal, instrumental, and electronic media and preparation of compositions for performance. Prerequisite: consultation with the director of the School of Music.

540. Introduction to Graduate Studies in Music Education (3) Bibliography; location and evaluation of reference materials; organization, form, and style in preparing music education research reports and other papers.

541. Contemporary Music Curricula in the Elementary School (3) Developing music curricula for the elementary school incorporating current theories, practices, materials, and research data.

542. Contemporary Music Curricula in Middle and Junior High Schools (3) Instructional materials, procedures, and curricular activities; integration with other subjects.

544. Review and Critique of New Band Literature (3) Review and analysis of new band literature; emphasis is on concert band literature for all school levels.

545. Psychological Foundations of Musical Behavior (3) Study of psychoacoustical effects of musical stimuli; emphasis on responses affecting learning musical ability, musical taste, and aesthetic reactions.

546. Selecting and Developing Measures of Musical Behavior (3) Constructing tests for musical measurement and examining existing standardized music measurement devices. Prerequisite: MUSIC 545.

547. The Materials of Appreciation (3) Examination of written and recorded materials and appropriate techniques for developing appreciation of music at elementary, secondary, and college levels.

549. Internship in Music Performance Techniques (1-6) This course is designed to provide teaching experiences for the student while working under the supervision of School of Music faculty members.

550. Wind and Percussion Materials (3) Survey of literature on the teaching of wind and percussion instruments, including solos, studies, and small ensembles. Prerequisite: MUSIC 540.

551. Adminstration and Supervision of School Music (3) Examination procedures for effective supervision of music instruction and administration of school music programs. Prerequisite: five years of music teaching in public schools.

552. Internship in Music Supervision (3-6) Internship in schools under supervision of graduate faculty in music education. Prerequisites: MUSIC 551, C & S 560.

559. Contemporary Music Education (3) This course examines contemporary trends in music education and places them within a framework of historical and philosophical significance. Prerequisites: 20 credits at the graduate level, including MUSIC 540.

*560. Orchestral and Choral Conducting (4 per semester, maximum of 16) Supervised conducting in selected performance situations, rehearsal techniques, and comprehensive score analysis.

572. Seminar in Musicology (3 per semester, maximum of 9) Research in selected areas of music history.

580. Studies in Orchestral Literature (3) Selected studies in orchestral literature from the seventeenth century to the present.

581. Studies in Chamber Music Literature (3) Selected studies in chamber music of all types from the seventeenth century to the present.

582. Studies in Keyboard Literature (3) Studies in special topics of keyboard literature, using lecture, analysis, and performance. Prerequisites: MUSIC 481, 482.

583. Studies in Choral Literature (3) Selected studies in choral literature of all types from the Renaissance to the present.

584. Studies in Operatic Literature (3) Studies in the development of the opera from 1600 to the present, treating both libretto and music.

585. Studies in Vocal Literature (3) Selected studies in solo vocal literature of all periods.

591. Graduate Degree Performance (1) A juried recital performance for students majoring in performance, composition, or conducting. Prerequisite: consent of the department.

594. Master's Paper Research (1-6) Investigation of a specific problem in music or music education.

596. Individual Studies (1-9)

597. Special Topics (1-9)

602. Supervised Experience in College Teaching (1-3 per semester, maximum of 6)

*Course may be scheduled only after consultation with the director of the School of Music.

NEUROSCIENCE (NEURO)

ROBERT B. PAGE, *Chair*
The Milton S. Hershey Medical Center
Hershey, PA 17033
717-531-6864

Degrees Conferred: Ph.D., M.S.

Senior Members of the Graduate Faculty
John D. Connor, Ph.D. (Philadelphia College of Pharmacy and Science) *Professor of Pharmacology*
Steven R. Goodman, Ph.D. (St. Louis) *Associate Professor of Physiology; Head, Multidisciplinary Laboratories*
Timothy S. Harrison, M.D. (Johns Hopkins) *Professor of Surgery and Physiology*

Richard A. Hawkins, Ph.D. (Harvard) *Professor of Anesthesia and Physiology; Chief, Division of Anesthesia and Metabolic Research*
Kathryn F. LaNoue, Ph.D. (Yale) *Professor of Physiology*
Alphonse E. Leure-dePree, Ph.D. (London-England) *Associate Professor of Anatomy*
Bryce L. Munger, M.D. (Washington-St. Louis) *Professor and Chair of Anatomy*
Robert B. Page, M.D. (Columbia) *Professor of Neurosurgery and Anatomy*
Cara-Lynne Schengrund, Ph.D. (Seton Hall) *Associate Professor of Biological Chemistry*
Walter B. Severs, Ph.D. (Pittsburgh) *Professor of Pharmacology*
Judith Weisz, M.B., B.Chir. (Newnham-England) *Professor of Obstetrics and Gynecology*
Jang-Yen Wu, Ph.D. (California-San Francisco) *Professor of Physiology*
Ian S. Zagon, Ph.D. (Colorado) *Professor of Anatomy*

Associate Members of the Graduate Faculty
Helen A. Baghdoyan, Ph.D. (Connecticut) *Assistant Professor of Anesthesia and Pharmacology*
Carey D. Balaban, Ph.D. (Chicago) *Assistant Professor of Anatomy*
Melvin L. Billingsley, Ph.D. (George Washington) *Associate Professor of Pharmacology*
Edward O. Bixler, Ph.D. (New Mexico) *Associate Professor of Psychiatry*
Robert M. Bryan, Jr., Ph.D. (British Columbia) *Assistant Professor of Neurosurgery and Physiology*
James R. Connor, Ph.D. (California-Berkeley) *Assistant Professor of Anatomy*
Barry R. Dworkin, Ph.D. (Rockefeller) *Associate Professor of Behavioral Science and Psychology*
Lyndon S. Hibbard, Ph.D. (Michigan State) *Research Associate in Anesthesia and Assistant Professor of Radiology*
Ralph Lydic, Ph.D. (Texas Tech.) *Associate Professor of Medicine and Physiology*
Ralph Norgren, Ph.D. (Michigan) *Professor of Behavioral Science*
Joan Y. Summy-Long, Ph.D. (Penn State-Hershey) *Associate Professor of Pharmacology*
Richard B. Tenser, M.D. (SUNY-Syracuse) *Associate Professor of Medicine (Neurology) and Microbiology*
Robert C. Vannucci, M.D. (Thomas Jefferson) *Associate Professor of Pediatrics*
Brian L. Wigdahl, Ph.D. (Medical College of Wisconsin) *Assistant Professor of Microbiology*

The Neuroscience program is an interdepartmental program within the College of Medicine and is designed to enable students to take an integrated series of courses leading to a M.S. and/or Ph.D. degree. The program encompasses both the fundamentals of neuroscience and advanced training in a specialized area.

All courses are available at The Milton S. Hershey Medical Center. The basic understanding of neuroanatomy, behavioral sciences, biochemistry, pharmacology, and physiology, as well as an introduction to neuroscience, constitutes a core program of study and is considered a requisite to the initiation of a meaningful research experience. In addition, students will become familiar with the fundamentals of one of the basic science disciplines (anatomy, biological chemistry, pharmacology, and physiology) taught in the College of Medicine. Competence in one of these disciplines will allow graduates to function as faculty members in either departments of neuroscience or in departments in each of these disciplines.

The students will then be candidates for degrees with a major in neuroscience and with a minor in one of the basic science disciplines. Graduate instruction in neuroscience is under the direction of the Neuroscience Advisory Committee composed of graduate faculty members representing the departments in the College of Medicine that actively participate in the Neuroscience program.

Admission Requirements
Scores from the Graduate Record Examination (GRE), or from a comparable substitute examination accepted by a graduate program and authorized by the dean of the Graduate School, are required for admission. At the discretion of a graduate program, a student may be admitted provisionally for graduate study in a program without these scores. Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin*.

Doctoral Degree Requirements
The formal course requirements depend upon the individual student's career goals. To be retained in the program and to continue to receive financial support, a student must maintain a B average. The student also must participate actively in the seminar program for at least two semesters. In addition, the student must complete successfully the following: (1) A candidacy examination covering the general course material that will consist of a written portion to test factual knowledge and an oral portion to examine research potential. The examination will be given at the end of the spring semester of the second year after the student has completed the required basic courses. (2) A communication requirement to be completed after the candidacy examination. (3) A comprehensive examination consisting

of a written and oral examination covering a specific topic relevant to, but not the same as, the student's research. (4) A research project consisting of an original investigation under the supervision of a neuroscience faculty adviser. (5) A thesis. (6) A final oral examination in defense of the thesis. The program is designed to be completed in four years, in most cases.

Student Aid

Graduate assistantships available in this program and other forms of student aid are described in the STUDENT AID section of the *Graduate Bulletin*.

NEUROSCIENCE (NEURO)

510. (PSIO 510) Neurobiology I (2) A general discussion on the cellular and molecular nature of the various aspects of neurophysiology.

511. (ANAT 511) Neurobiology II (3) Structure and physiology of central and peripheral nervous systems, including specific sense organs.

515. (ANAT 515) Developmental Neurobiology (2) Development of the nervous system in all its aspects.

526. (PSIO 526) Molecular Neuroscience (2) An in-depth discussion of the molecular nature of various components of neurotransmission. Prerequisite: PSIO 510 or NEURO 510.

527. (PSIO 527) Neurobiology of the Visual System (2) This course provides a detailed knowledge of the molecular and cellular mechanism of the visual processes. Prerequisite: PSIO 510 or NEURO 510.

528. (BCHEM 528) Neurochemistry (3) Study at the molecular level of processes that permit cells of the central nervous system to perform their unique functions. Prerequisites: BCHEM 502, 505; PSIO 510 or NEURO 510.

529. (BEHSC 529) Neural Bases of Behavior (2) Study of neural mechanisms that control an organism's interaction with the external environment. Prerequisite: PSIO 510 or NEURO 510. Prerequisite or concurrent: ANAT 511 or NEURO 511.

542. (ANAT 542) Comparative Neurology (3) Topics in functional anatomy and neurophysiology; the comparative approach to the organization of the mammalian nervous system will be stressed. Prerequisite: ANAT 511 or NEURO 511.

543. (ANAT 543) Sensory Processes (3) Morphological, physiological, and psychological aspects of mammalian sensory systems, emphasizing somatic, sensory, visual, and auditory systems. Prerequisite: ANAT 511 or NEURO 511.

545. (ANAT 545) Comparative Auditory and Visual Anatomy (3) An introduction to the morphology and evolution of the vertebrate eye and ear; individualized laboratory work arranged by consultation.

550. (PHARM 550) Neuropharmacology (3) Study of mechanisms of action of drugs that alter neuronal transmission in the peripheral and central nervous systems. Prerequisite: NEURO 510 or PSIO 510.

590. Colloquium (1-3)

594. Research Topics (1-18)

596. Individual Studies (1-9)

597. Special Topics (1-9)

NUCLEAR ENGINEERING (NUC E)

EDWARD H. KLEVANS, *Head of the Department*
231 Sackett Building
814-865-4911

Degrees Conferred: Ph.D., M.S., M.Eng.

Senior Members of the Graduate Faculty
Anthony J. Baratta, Ph.D. (Brown) *Associate Professor of Nuclear Engineering*
Gary L. Catchen, Ph.D. (Columbia) *Assistant Professor of Nuclear Engineering*
Ward S. Diethorn, Ph.D. (Carnegie Tech.) *Professor of Nuclear Engineering*
Anthony H. Foderaro, Ph.D. (Pittsburgh) *Professor of Nuclear Engineering*
William A. Jester, Ph.D. (Penn State) *Professor of Nuclear Engineering*
Edward S. Kenney, Ph.D. (Penn State) *Professor of Nuclear Engineering*
Edward H. Klevans, Ph.D. (Michigan) *Professor of Nuclear Engineering*
Samuel H. Levine, Ph.D. (Pittsburgh) *Professor of Nuclear Engineering*
K. K. S. Pillay, Ph.D. (Penn State) *Adjunct Associate Professor of Nuclear Engineering*
Forrest J. Remick, Ph.D. (Penn State) *Professor of Nuclear Engineering*

Associate Members of the Graduate Faculty
Ming-Yuan Hsiao, Ph.D. (Illinois) *Assistant Professor of Nuclear Engineering*
Thomas F. Lin, Ph.D. (Rensselaer) *Research Associate, Applied Research Laboratory; Assistant Professor of Nuclear Engineering*
John H. Mahaffy, Ph.D. (Colorado) *Research Associate, Applied Research Laboratory; Assistant Professor of Nuclear Engineering*
Robert T. McGrath, Ph.D. (Michigan) *Adjunct Assistant Professor of Nuclear Engineering*
G. E. Robinson, Ph.D. (Penn State) *Associate Professor of Nuclear Engineering*

Programs of study are individually tailored, and engineering is emphasized through the study of reactor principles — computational methods, transport theory, and nuclear design; plasma principles — waves, analysis, and fusion laboratory; shielding — Monte Carlo and transport methods; reactor systems design — thermal, mechanical, and control; reactor fuels — configuration, radiation effects, and fuel cycle management; isotope utilization — activation analysis, chemical processes including nuclear medicine; safety analysis — reactor siting, engineered safeguards, environmental effects, probabilistic risk analysis, and digital handling and analysis of nuclear data.

Admission Requirements
Scores from the Graduate Record Examination (GRE), or from a comparable substitute examination accepted by a graduate program and authorized by the dean of the Graduate School, are required for admission. At the discretion of a graduate program, a student may be admitted provisionally for graduate study in a program without these scores. Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin.*

Students with a 2.50 junior-senior average and with appropriate course backgrounds will be considered for admission. General aptitude GRE test results are required. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

Degree Requirements
The department offers three degrees at the master's level: M.Eng., M.S. with paper, and M.S. with thesis. The communication requirement for the Ph.D. degree may be satisfied by proficiency in English. Continuous registration is required for all graduate students until the thesis or engineering report is approved.

Student Aid
In addition to the fellowships, traineeships, graduate assistantships, and other forms of financial aid described in the STUDENT AID section of the *Graduate Bulletin,* the following awards typically have been available to graduate students in this program:

INSTITUTE OF NUCLEAR POWER OPERATIONS FELLOWSHIPS — Available to graduate students in nuclear engineering; stipend $7,000 plus tuition.

U.S. Department of Energy - Magnetic Fusion Science Fellowship —Available to students interested in graduate study in magnetic fusion science; stipend $1,000/month plus tuition.

U.S. Department of Energy - Nuclear Science and Engineering and Health Physics Fellowships — Available to graduate students interested in engineering and engineering support related to nuclear technology and health physics; stipend $1,200/month plus tuition.

NUCLEAR ENGINEERING (NUC E)

401. Introduction to Nuclear Engineering (3)
403. Advanced Reactor Design (3)
405. (CHEM 405) Nuclear and Radiochemistry (3)
408. Radiation Shielding (3)
420. Radiological Safety (3)
428. Radioactive Waste Control (3)
430. Design Principles of Reactor Systems (3)
431. Synthesis of Nuclear Systems (3)
444. Nuclear Reactor Operations Laboratory (1)
445. Nuclear Digital Instrumentation (3)
450. Radiation Detection and Measurement (3)
451. Experiments in Reactor Physics (3)
460. Nuclear Systems Risk Assessment (3)
490. (AERSP 490, E E 490) Introduction to Plasmas (3)
494. Senior Thesis (1-9)
496. Independent Studies (1-18)
497. Special Topics (1-9)

501. Reactor Engineering (3) Reactor controls, shielding of nuclear reactors, stress analysis of reactor materials, power cycle analysis, breeding, and advanced design considerations. Prerequisites: NUC E 302; NUC E 430 or M E 412.

503. Thermonuclear Engineering (3) Binary fusion reactions; microscopic and macroscopic phenomena in a completely ionized gas; electromagnetic confinement; design, operation, and diagnostics of experiments. Prerequisite: NUC E 490.

505. Reactor Instrumentation and Control (3) Neutron-detecting instruments and circuits; in-core power instrumentation; reactor control principles; control mechanisms; operational control problems. Prerequisite: NUC E 302.

512. Nuclear Fuel Management (3) Nuclear fuel inventory determination and economic value through the fuel cycle. Emphasis on calculational techniques in reactor, optimization, and design. Prerequisite: NUC E 302.

521. Neutron Transport Theory (3) Derivation of Boltzmann equation for neutron transport; techniques of approximate and exact solution for the monoenergetic and spectrum regenerating cases. Prerequisite: NUC E 403 or PHYS 406.

540. (AERSP 540, E E 540) Theory of Plasma Waves (3) Solutions of the Boltzmann equation; waves in bounded and unbounded plasmas; radiation and scattering from plasmas. Prerequisite: NUC E (AERSP, E E) 490.

541. (E E 541) Plasma Theory (3) Advanced topics in kinetic theory, fluctuation theory, microinstability, and turbulence. Prerequisite: NUC E (AERSP, E E) 490.

590. Colloquium (1-3)

596. Individual Studies (1-9)

597. Special Topics (1-9)

602. Supervised Experience in College Teaching (1-3 per semester, maximum of 6)

NURSING (NURS)

ELIZABETH J. SUSMAN, *Professor-in-Charge*
201 Health and Human Development East Building
814-863-0245

Degree Conferred: M.S.

Senior Member of the Graduate Faculty
Elizabeth J. Susman, Ph.D. (Penn State) *Associate Professor of Nursing*

Associate Members of the Graduate Faculty
Madalon Amenta, Dr.P.H. (Pittsburgh) *Associate Professor of Nursing*
Jorge Grimes, Ed.D. (SUNY-Buffalo) *Associate Professor of Nursing*
Lois S. Kelley, D.Ed. (Penn State) *Assistant Professor of Nursing*
Patricia B. Koch, Ph.D. (Penn State) *Assistant Professor of Nursing*
Grace Laubach, M.A. (Columbia) *Associate Professor of Nursing*
Phyllis K. Mansfield, Ph.D. (Penn State) *Assistant Professor of Nursing*
Deborah B. Preston, R.N., Ph.D. (Penn State) *Assistant Professor of Nursing*
Judith Vicary, Ph.D. (Penn State) *Assistant Professor of Nursing*
Janet A. Williamson, Ph.D. (Penn State) *Associate Professor of Nursing*
Elaine W. Young, Ph.D. (Penn State) *Assistant Professor of Nursing*

The Master of Science degree is offered in recognition of the completion of a program that emphasizes productive scholarship and research in preparation of the advanced nursing specialist. The program is accredited by the National League for Nursing (NLN). A minor in Nursing is offered at the doctoral level.

The Nursing Consultation Center, located on the first floor of the Nursing Building, has a nursing practice facility that provides a setting for students and faculty to test and implement a nursing practice model consistent with the philosophy and objectives of the Nursing program. It provides examination rooms, small and large conference rooms, rooms with two-way viewing and television recording facilities, and rooms specially furnished for group work with children, youths, adults, and the elderly. It is arranged to provide for nursing practice and research in the care of individuals, families, and groups.

Admission Requirements

Scores from the Graduate Record Examination (GRE), or from a comparable substitute examination accepted by a graduate program and authorized by the dean of the Graduate School, are required for admission. At the discretion of a graduate program, a student may be admitted provisionally for graduate study in a program without these scores. Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin*.

Applicants should hold a baccalaureate degree in nursing from an NLN-accredited program and must submit the official results of the Graduate Record Examination. A junior-senior grade-point average of 3.00 is expected for undergraduate work. Courses in basic statistics and introduction to research are required. Applicants who do not meet the established criteria may be considered on an individual basis.

Degree Requirements

Candidates for the Master of Science degree must earn a minimum of 36 credits. A core of courses in nursing theory, research, and advanced nursing is required of all students. Students must select an area of specialization in nursing from among child and adolescent health, young and middle-aged adult health, older adult health, family health, and community health. Functional preparation is required in teaching, administration, or practice. In addition, each student must complete a thesis.

Student Aid

In addition to the fellowships, traineeships, graduate assistantships, and other forms of financial aid described in the STUDENT AID section of the *Graduate Bulletin,* the following awards typically have been available to graduate students in this program:

U.S. Public Health Service Traineeships in Nursing — Open to selected registered nurse students in nursing; stipend may be available plus tuition. Apply to Professor in Charge, Graduate Program in Nursing.

NURSING (NURS)

400. Professional Role Development (3)
401. Concepts of Health (3)
402. Holistic Health (3)
405. Occupational Health Nursing (3)
410. Nursing Care of the Family in the Community (4)
415. Community Health Nursing (3)
425. School Health Nursing (3)
445. Trauma Nursing (3)
450. Rehabilitation Nursing (3)
455. Nursing Related to Complex Health Patterns I (3)
460. Nursing Related to Complex Health Patterns II (3)
464. Dying and Death (3)
495. Nursing Study in Specialized Setting (1-12)
496. Independent Studies (1-18)
497. Special Topics (1-9)
499. Foreign Study — Nursing (1-9)

501. Issues in Nursing and Health Care (2) Consideration of personal, social, political, economic, philosophical, ethical problems/questions and ways of confronting and resolving conflicts in professional practice.

510. Theoretical Foundations of Nursing (3) Examines current conceptual models in nursing and relationship of empirical data and existing theories to the development of nursing science.

511. Design and Analysis of Clinical Studies in Nursing (3) Analysis and critical evaluation of nursing research with emphasis on designs appropriate to nursing phenomena. Prerequisite: ED PSY 406 or SOC 470 or an intermediate statistics course.

512. Models of Nursing Practice (3) Integration and application of current nursing theory and research to the development of a model of nursing practice. Prerequisites: NURS 510, 511.

514. Nursing Strategies for Child and Adolescent Health (3) Development of a conceptual framework for nursing practice with children/adolescents through analysis and synthesis of selected theories and research. Prerequisite: NURS 512.

516. Nursing Strategies for Adult Health (3) Development of a conceptual framework for nursing practice with adults through analysis and synthesis of selected theories and research. Prerequisite: NURS 512.

524. Nursing Strategies for Older Adult Health (3) Development of a conceptual framework for nursing practice with older adults through analysis and synthesis of selected theories and research. Prerequisite: NURS 512.

526. Nursing Strategies for Family Health (3) Development of a conceptual framework for nursing practice with families through the analysis and synthesis of selected theories and research. Prerequisite: NURS 512.

528. Nursing Strategies for Community Health (3) Development of a conceptual framework for nursing practice with communities through the analysis and synthesis of selected theories and research. Prerequisite: NURS 512.

530. Clinical Process in Nursing Practice (1-10) Application of a model of nursing practice to a selected client population. Prerequisite: completion of advanced nursing theory courses in selected clinical areas.

550. Transcultural Health Nursing (3) Theoretical background for design, implementation, evaluation of nursing care to promote, maintain, and restore health, congruent with cultural patterns.

590. Colloquium (1-3)

596. Individual Studies (1-9)

597. Special Topics (1-9)

602. Supervised Experience in College Teaching (1-3 per semester, maximum of 6)

NUTRITION (NUTR)

HELEN A. GUTHRIE, *In Charge of Graduate Programs in Nutrition*
106 Henderson Building
814-863-0772

Degrees Conferred: Ph.D., M.S.; M.Ed. in Human Nutrition

Senior Members of the Graduate Faculty
Craig R. Baumrucker, Ph.D. (Purdue) *Associate Professor of Animal Nutrition — Physiology*
John L. Beard, Ph.D. (Cornell) *Assistant Professor of Nutrition*
Elsworth Buskirk, Ph.D. (Minnesota) *Professor of Applied Physiology*
Terry D. Etherton, Ph.D. (Minnesota) *Professor of Animal Nutrition*
Gary J. Fosmire, Ph.D. (California) *Associate Professor of Nutrition Science*
Michael H. Green, Ph.D. (California) *Associate Professor of Nutrition Science*
Helen A. Guthrie, Ph.D. (Hawaii) *Professor of Nutrition*
Truman V. Hershberger, Ph.D. (Ohio State) *Associate Professor of Animal Nutrition*
Arun Kilara, Ph.D. (Nebraska) *Associate Professor of Food Science*
Penny M. Kris-Etherton, Ph.D. (Minnesota) *Associate Professor of Nutrition*
Roland M. Leach, Jr., Ph.D. (Cornell) *Professor of Poultry Science*
Gerald E. McClearn, Ph.D. (Wisconsin) *Professor of Nutrition*
Lawrence D. Muller, Ph.D. (Purdue) *Professor of Dairy Science*
C. Channa Reddy, Ph.D. (Indian Inst. of Science) *Associate Professor of Veterinary Science*
Richard Rose, Ph.D. (Michigan State) *Professor of Physiology and Surgery*
L. D. Satterlee, Ph.D. (Iowa State) *Professor of Food Science*
Richard W. Scholz, Ph.D. (Purdue) *Professor of Veterinary Science*
Barbara M. Shannon, Ph.D. (Purdue) *Professor of Nutrition*
Laura S. Sims, Ph.D. (Michigan State) *Associate Professor of Nutrition in Public Health*
John Edgar Smith, Ph.D. (Nebraska) *Associate Professor of Nutrition*
Paul J. Wangsness, Ph.D. (Iowa State) *Professor of Animal Nutrition*
Helen S. Wright, Ph.D. (Penn State) *Associate Professor of Nutrition*

Associate Members of the Graduate Faculty
Stephen M. Abrams, Ph.D. (Florida) *Adjunct Assistant Professor of Dairy Science*
Cheryl Achterberg, Ph.D. (Cornell) *Assistant Professor of Nutrition*
Dorothy Blair, Ph.D. (Cornell) *Assistant Professor of Nutrition*
J. Lynn Brown, Ph.D. (MIT) *Assistant Professor of Human Nutrition Extension*
Geoffrey Greene, Ph.D. (Penn State) *Assistant Professor of Nutrition*
Harold W. Harpster, Ph.D. (Michigan State) *Associate Professor of Animal Nutrition*
A. J. Heinrich, Ph.D. (Ohio State) *Assistant Professor of Dairy and Animal Science*
Ronald S. Kensinger, Ph.D. (Florida) *Assistant Professor of Animal Nutrition — Physiology*
William B. Roush, Ph.D. (Oregon State) *Assistant Professor of Poultry Science*
Thomas W. Sweeney, Ph.D. (Kentucky) *Assistant Professor of Dairy Science*
Donald B. Thompson, Ph.D. (Illinois) *Assistant Professor of Food Science*
Gabriella A. Varga, Ph.D. (Maryland) *Assistant Professor of Animal Science*
Robert Yeh, Ph.D. (Illinois) *Associate Professor of Nutrition*
R. Vasilatos Younken, Ph.D. (Penn State) *Assistant Professor of Poultry Science*

Graduates are prepared for careers in basic and applied research in nutrition and in college teaching. The course of study is planned to meet the professional objectives of the individual student. Students may emphasize nutrition science, applied human nutrition, applied animal nutrition, nutrition education, and nutrition in public health. Supporting courses are available in biochemistry, physiology, genetics, microbiology, biophysics, food science, education, health planning and administration, individual and family studies, anthropology, sociology, and psychology.

Current research emphasizes trace elements, vitamin A, lipid metabolism, nutrition and behavior, nutrition education strategies, and evaluation of dietary intake and nutritional status and nutrition policy.

Facilities include well-equipped nutrition science laboratories with animal facilities supervised by a University laboratory animal resource staff. The Nutrition Information and Resource Center and the program in nutrition education serve as a laboratory for students in community nutrition and nutrition education, and the Nutrition Clinic serves this function for those in clinical nutrition.

Admission Requirements

Scores from the Graduate Record Examination (GRE), or from the Medical College Admission Test (MCAT), are required for admission. At the discretion of a graduate program, a student may be admitted provisionally for graduate study in a program without these scores. Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin*.

College graduates with an undergraduate degree in nutrition, animal sciences, food science, dietetics, or a related biological or social science will be considered for admission. Applicants should have a minimum grade-point average of 3.00 (A = 4.00), an acceptable score on the GRE (an average quantitative and verbal score above the 50th percentile), and two supporting recommendations. Exceptions may be made for students with special backgrounds, abilities, and interests. When openings are limited, the best-qualified candidates are given priority.

The basic expectations for admission from undergraduate studies include 6 credits in chemistry (organic and inorganic); 3 credits each in physiology, biochemistry, and nutrition; and physics, calculus, and analytical chemistry for some research areas in nutrition science and social science for public health and community nutrition. Students with more than 9 credits of deficiency and a superior record may be admitted as provisional students until they qualify for consideration for regular degree status. Deficiencies are expected to be made up with a 3.00 grade-point average or better within the first two semesters.

Master's Degree Requirements

The graduate program in Nutrition offers the M.S. degree with an emphasis in nutrition science, applied human nutrition, applied animal nutrition, nutrition education, or nutrition in public health. The M.Ed. degree is offered with an emphasis in nutrition education or nutrition in public health.

The M.S. degree requires 36 credits of course work, including 6 credits in research (NUTRN 600). The M.Ed. degree requires 45 credits of course work, including 6 credits in a field of professional education. The M.S. and M.Ed. degrees with an emphasis on nutrition in public health include a 4-credit field experience (NUTR 555).

Doctoral Degree Requirements

Students are admitted on a provisional basis pending satisfactory completion of the candidacy examination designed to assess the student's potential and academic preparation for doctoral study. Candidacy examinations must be scheduled by students with a master's degree after they have completed 10 credits in doctoral work but before the end of the second semester following admission to the graduate program. The candidacy examination is administered and evaluated by the Graduate Candidacy Committee.

Communication and Language Requirement. Doctoral students must demonstrate competency in spoken English as judged by the program faculty and in technical writing by completion of ENGL 418 with a grade of B or better. Students also must complete satisfactorily 2 to 3 credits at the 400 or 500 level from any one of the following areas: (1) college teaching; (2) logic or philosophy of science; (3) foreign language; or (4) computer science. There are no specific course requirements; however, the academic program is developed by the student in consultation with his or her adviser to develop doctoral-level competence in nutrition and one or more supporting areas.

Students are expected to participate in a colloquium each semester and enroll in a seminar on a regular basis.

Student Aid

In addition to the fellowships, traineeships, graduate assistantships, and other forms of financial aid described in the STUDENT AID section of the *Graduate Bulletin*, the following awards typically have been available to graduate students in this program:

Kraft Fellowships in Nutrition Education — Two $5,000 awards per year to master's or doctoral students.

ANIMAL NUTRITION (A NTR)

401. Physiology of Nutrition (3)
496. Independent Studies (1-18)
497. Special Topics (1-9)

505. Ruminology (3) Physiological, biochemical, and microbiological activities occurring within the rumen and the relation of rumen function to animal response. Prerequisites: at least one course in each of the following areas: animal nutrition, physiology, microbiology, and biochemistry.

590. Colloquium (1-3)

596. Individual Studies (1-9)

597. Special Topics (1-9)

NUTRITION (NUTR)

400. Introduction to Nutrition Counseling (1-3)
420. Experimental Foods (4)
421. Cultural Aspects of Foods (3)
422. Advanced Foods (3)
430. (S T S 430) Global Food Strategies: Problems and Prospects for Reducing World Hunger (3)
450. Principles of Human Nutrition (3)
451. Developmental Nutrition (2)
452. Nutritional Aspects of Disease (3)
453. Diet in Disease (3)
454. Laboratory Methods in Nutrition (3)
456. Community Nutrition (2)
459. Advanced Nutrition (3)
490. Foods and Nutrition Seminar (1)
495. Advanced Field Experience in Nutrition (1-6)
496. Independent Studies (1-18)
497. Special Topics (1-9)

522. Advanced Experimental Foods (3) Experimental methods used in measuring the quality of foods; specific problems in food preparation.

530. Problems in Foods and Nutrition (1-6)

550. Readings in Nutrition (3) Readings and reports of selected topics in nutrition.

555. Field Work in Nutrition (2-4) Field problems planned to meet the needs of individual students. Hours and problems to be arranged.

556. The Survey Method in Foods and Nutrition (2) Study of survey techniques as a tool in the assay of food adequacy and nutritional status.

561. Public Health Nutrition: Programs/Services (2) Organization of the nutrition component of programs administered by health agencies; application of knowledge and skills to effect planned change. Prerequisite: NUTR 560.

NUTRITION (NUTRN)

500. Nutrition and Metabolic Regulation (3) The integration of physiological and biochemical processes as they relate to nutrition. Prerequisites: A NUTR 401 or NUTR 450; BIOCH 437; FD SC 401.

501. Energy Metabolism (3) Integration of biochemical, nutritional, and physiological processes in energy metabolism; concepts underlying the application of bioenergetics and calorimetry to metabolism. Prerequisites: BIOCH 402; 3 credits each in nutrition and physiology.

502. Vitamin Metabolism (3) A detailed treatment of metabolism and metabolic roles of vitamins, therapeutic uses of vitamins, and dangers of vitamin toxicity. Prerequisites: 3 credits each in biochemistry, nutrition, and physiology.

503. Mineral Nutrition and Metabolism (2) Functional approach to the nutrition and metabolism of the mineral elements by animals and humans. Prerequisites: 3 credits each in biochemistry, nutrition, and physiology.

504. Amino Acid Metabolism and Protein Nutrition (3) Fundamental principles of amino acid metabolism and applied aspects of protein nutrition in the physiology of mammals. Prerequisites: BIOCH 437; NUTR 450 or A NTR 401; FD SC 401.

506. (AN SC 506) Ruminology (3) Physiological, biochemical, and microbiological activities occurring within the rumen and the relation of rumen function to animal response. Prerequisites: at least one course in each of the following areas; animal nutrition, physiology, microbiology, and biochemistry.

511. Maternal and Infant Nutrition (2) Physiological and psychosocial factors affecting human nutritional needs and feeding practices during the life-cycle stages of pregnancy, lactation, and infancy. Prerequisite: NUTR 451.

512. Nutrition and Aging (2) Consideration of physiological and psychological changes influencing nutritional status of the aged; nutrient requirements; nutrient-disease interactions; nutritional care of the elderly. Prerequisite: NUTR 452.

513. Atherosclerosis and Nutrition (2) The etiology and pathophysiology of atherosclerotic cardiovascular disease, with emphasis on nutritionally-related aspects. Prerequisite: NUTR 452.

514. (V SC 514) Prostaglandins and Leukotrienes (3) Biochemical, physiological, and nutritional aspects of arachidonic acid and related essential fatty acid metabolism. Structure-activity relationships of prostaglandins, prostacyclins, thromboxanes, and leukotrienes. Prerequisite: BIOCH 402 or 437.

515. Mathematical Modeling in Nutrition (2) Study of the theory and application of mathematical modeling of the tracer and tracee kinetics of nutrients and their metabolites in animals and humans. Prerequisites: NUTRN 500, 6 credits in calculus.

521. National Nutrition Policy (1) Description of major structures, factors, and issues in national nutrition policy. Implications for nutrition research and services.

551. Seminar in Nutrition (1-6) Selected topics and recent advances in nutrition.

560. Planning and Evaluating Nutrition Programs (3) Administration of public health nutrition programs, including community assessment program planning, implementation, and evaluation.

590. Colloquium (1-3)

596. Individual Studies (1-9)

597. Special Topics (1-9)

602. Supervised Experience in College Teaching (1-3 per semester, maximum of 6)

OPERATIONS RESEARCH (O R)

M. ROSENSHINE, *Chair of the Committee on Operations Research*
207 Hammond Building
814-863-2356

Degrees Conferred: Students electing this option through participating programs will earn a degree with a dual title at both the Ph.D. and the M.S., M.A., or M.Eng. levels, i.e., Ph.D. in (graduate program name) and Operations Research, or M.S., M.A., or M.Eng. in (graduate program name) and Operations Research.

Senior Members of the Graduate Faculty
Charles E. Antle, Ph.D. (Oklahoma State) *Professor of Statistics*
Leonard G. Austin, Ph.D. (Penn State) *Professor of Materials Science*
James G. Beierlein, Ph.D. (Purdue) *Associate Professor of Agricultural Economics*
Michael S. Bronzini, Ph.D. (Penn State) *Professor of Civil Engineering*
Tom Cavalier, Ph.D. (Virginia Polytechnic) *Assistant Professor of Industrial Engineering*
M. Jeya Chandra, Ph.D. (Syracuse) *Associate Professor of Industrial Engineering*
Kalyan Chatterjee, Ph.D. (Harvard) *Associate Professor of Management Science*
Goong Chen, Ph.D. (Wisconsin) *Associate Professor of Mathematics*
David Christy, Ph.D. (Georgia) *Assistant Professor of Management Science*

Samuel G. Davis, Ph.D. (Syracuse) *Associate Professor of Management Science*
James W. Dunn, Ph.D. (Oklahoma State) *Associate Professor of Agricultural Engineering*
Ernest E. Enscore, Jr., Ph.D. (Penn State) *Professor of Industrial Engineering*
Rodney A. Erickson, Ph.D. (Washington) *Professor of Geography*
Turgay Ertekin, Ph.D. (Penn State) *Professor of Petroleum and Natural Gas Engineering*
Richard L. Gordon, Ph.D. (MIT) *Professor of Mineral Economics*
Peter R. Gould, Ph.D. (Northwestern) *Professor of Geography*
William W. Hager, Ph.D. (MIT) *Professor of Mathematics*
Milton C. Hallberg, Ph.D. (Iowa State) *Professor of Agricultural Economics*
William L. Harkness, Ph.D. (Michigan State) *Professor of Mathematical Statistics*
Terry Harrison, Ph.D. (Tennessee) *Associate Professor of Management Science*
William T. Hartman, Ph.D. (Oregon) *Associate Professor of Education*
Jack C. Hayya, Ph.D. (UCLA) *Professor of Management Science*
George Heitmann, Ph.D. (Princeton) *Professor of Management Science*
Michael P. Hottenstein, D.B.A. (Indiana) *Professor of Management*
Teh-Wei Hu, Ph.D. (Wisconsin) *Professor of Economics*
David F. Kibler, Ph.D. (Colorado State) *Professor of Civil Engineering*
George B. Kleindorfer, Ph.D. (Carnegie-Mellon) *Associate Professor of Quantitative Business Analysis*
C. Gregory Knight, Ph.D. (Minnesota) *Professor of Geography*
Allan M. Krall, Ph.D. (Virginia) *Professor of Mathematics*
Gerard Lallement, Doctorat es Mathématiques (Paris) *Professor of Mathematics*
Samuel Levine, Ph.D. (Pittsburgh) *Professor of Nuclear Engineering*
Gary L. Lilien, D.E.S. (Columbia) *Research Professor of Business Administration*
Peter T. Luckie, Ph.D. (Penn State) *Professor of Mineral Processing*
A. K. Mahalanabis, Ph.D. (Calcutta-India) *Professor of Electrical Engineering*
Stuart H. Mann, Ph.D. (Case Western Reserve) *Professor of Operations Research*
George J. McMurtry, Ph.D. (Purdue) *Professor of Electrical Engineering*
Deborah J. Medeiros, Ph.D. (Purdue) *Associate Professor of Industrial Engineering*
Jan M. Mutmansky, Ph.D. (Penn State) *Associate Professor of Mineral Science*
Wayne L. Myers, Ph.D. (Michigan) *Associate Professor of Forest Biometrics*
Jon P. Nelson, Ph.D. (Wisconsin) *Professor of Economics*
J. Keith Ord, Ph.D. (London) *Professor of Management Science and Statistics*
Claude D. Pegden, Ph.D. (Purdue) *Associate Professor of Industrial Engineering*
Raja V. Ramani, Ph.D. (Penn State), P.E. *Professor of Mining Engineering*
Edward T. Reutzel, Ph.D. (Penn State) *Associate Professor of Management Science*
Paul H. Rigby, Ph.D. (Texas) *Professor of Business Administration*
Matthew Rosenshine, Ph.D. (SUNY) *Professor of Industrial Engineering*
Allen L. Soyster, Ph.D. (Carnegie-Mellon) *Professor of Industrial and Management Systems Engineering*
H. Randolph Thomas, Jr., Ph.D. (Vanderbilt) *Professor of Civil Engineering*
Robert D. Weaver, Ph.D. (Wisconsin) *Associate Professor of Agricultural Economics*
Robert Wells, Ph.D. (Princeton) *Associate Professor of Mathematics*
Jack H. Willenbrock, Ph.D. (Penn State), P.E. *Professor of Civil Engineering*
Anthony V. Williams, Ph.D. (Michigan State) *Associate Professor of Geography*
Donald J. Willower, Ed.D. (Buffalo) *Professor of Education*

Associate Members of the Graduate Faculty
G. Mike Charleston, Ph.D. (Penn State) *Associate Professor of Education*
Stephen Fairweather, Ph.D. (Penn State) *Assistant Professor of Forest Resources Management*
Jill Findeis, Ph.D. (Washington State) *Assistant Professor of Agricultural Economics*
Jack Kirkland, Ph.D. (Washington State) *Assistant Professor of Agricultural Economics*
Joseph Lambert, Ph.D. (Purdue) *Associate Professor of Computer Science and Mathematics*
Patrick Lee, Ph.D. (Carnegie-Mellon) *Assistant Professor of Business Administration*
William T. McSweeny, Ph.D. (Virginia Polytechnic) *Assistant Professor of Agricultural Economics*
Brian Melloy, Ph.D. (South Florida) *Assistant Professor of Industrial Engineering*
Panayote Pardalos, Ph.D. (Minnesota) *Assistant Professor of Computer Science*
William Burdette Roush, Ph.D. (Oregon State) *Assistant Professor of Poultry Science*
James S. Shortle, Ph.D. (Iowa State) *Assistant Professor of Agricultural Economics*
Spiro Stefanou, Ph.D. (California-Davis) *Assistant Professor of Agricultural Economics*
Ken Tomiyama, Ph.D. (UCLA) *Assistant Professor of Electrical Engineering*

The Operations Research dual-title degree program option is administered by an Operations Research Committee, which is responsible for management of the program. The committee maintains program definition, identifies faculty and courses appropriate to the option, and recommends policy and procedures for its operation to the dean of the Graduate School. This dual-title degree program is offered as an option through graduate major programs in eight colleges. The option enables students from diverse graduate programs to attain and be identified with the tools, techniques, and methodology of

operations research, while maintaining a close association with areas of application. Operations research is the analysis — usually involving mathematical treatment — of a process, problem, or operation to determine its purpose and effectiveness and to gain maximum efficiency. To pursue a dual-title degree under this program option the student must apply to the Graduate School and register through one of the following graduate major programs: Agricultural Economics, Agricultural Engineering, Business Administration, Civil Engineering, Community Systems Planning, Computer Science, Economics, Educational Administration, Electrical Engineering, Entomology, Forest Resources, Geochemistry and Mineralogy, Geography, Industrial Engineering, Mathematics, Mechanical Engineering, Mineral Economics, Mining Engineering, Petroleum and Natural Gas Engineering, Poultry Science, or Statistics.

Admission Requirements

Scores from the Graduate Record Examination (GRE), or from a comparable substitute examination accepted by a graduate program and authorized by the dean of the Graduate School, are required for admission. At the discretion of a graduate program, a student may be admitted provisionally for graduate study in a program without these scores. Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin*.

There are no prerequisites for admission to the M.S., M.Eng., or M.A. program option other than those that may be imposed by the participating graduate major programs.

For the Ph.D. degree with Operations Research option, in addition to those prescribed by the graduate major program, prerequisites for acceptance to the program without deficiency include the following or their equivalent: MATH 140, 141, 231, 251, and 220; CMPSC 101; and 6 credits in elementary or introductory micro- or macroeconomics.

Degree Requirements

To qualify for a dual-title degree, students must satisfy the requirements of the graduate major programs in which they are enrolled, in addition to the minimum requirements, or their equivalent, in the Operations Research option. Students must enroll in O R 590, Colloquium, for at least 1 credit in each year enrolled in the program and in residence.

For the M.S. or M.A. degree with Operations Research option, 18 credits are required from the areas of statistical methods, computer science, optimization (survey-level courses acceptable), processes (survey-level courses acceptable), and applications. (Application courses are those that involve problem solving through the use of decision methods.) At least 3 credits must be selected from each area. Particular courses may satisfy both the graduate major program requirements and those in the Operations Research option.

A thesis may be required, the supervisor of which must be a member of the Graduate Faculty recommended by the chair of the program granting the degree and approved by the Operations Research Committee as qualified to supervise thesis work in operations research. A paper or report may be written in lieu of the M.S. or M.A. thesis upon approval of the student's graduate major program. An M.Eng. student or a student selecting the paper or report must take an additional 6 credits in the Operations Research program. It is the prerogative of the graduate major program to assign these credits to one or more of the following categories: statistical methods, computer science, optimization, processes, and applications.

The minimum requirements for the Ph.D. degree with Operations Research option are (1) Mathematics — 9 credits minimum, including real analysis (MATH 401, 402) and linear algebra (MATH 436 or 441); (2) Statistics — 9 credits minimum with a 6-credit sequence in mathematical statistics (STAT 409, 410) (STAT 414, 415) or in experimental statistics (STAT 451, 460) and 3 credits in stochastic processes (STAT 416 or I E 516); (3) Optimization — 12 credits minimum, including linear programming I and II, mathematical programming I or II or III, and dynamic programming; (4) Processes — 9 credits minimum, including inventory models, scheduling models, and waiting line models; (5) Computational Methods and Simulation Methods, including 3 credits from each area; and (6) Open Areas (application and/or specialization) — 15 credits minimum.

A Ph.D. minor program in Operations Research is available for doctoral students in graduate programs who find it advantageous to include advanced quantitative methods of systems analysis in their program of study and have been approved to do so by their doctoral committee. To qualify for a minor in Operations Research, students must satisfy the requirements of their graduate major program and take at least 15 credits from the following areas: statistical methods or mathematical statistics, computer science, optimization, and processes. At least 3 credits must be taken from each of optimization and processes areas as listed below.

The doctoral committee is recommended by the graduate major program granting the degree. The chair and at least two members of a doctoral committee must be members of the Graduate Faculty and

approved by the Operations Research Committee as qualified to supervise doctoral theses in operations research. The Operations Research Committee is responsible for administering an examination in operations research which constitutes a portion of the comprehensive examination administered to the doctoral student in the program option, as well as to the candidate who chooses operations research as a minor field.

Courses of a like nature identified as the core of the program option have been given generic names and descriptions. Each such listing may be satisfied by one of the courses given under it.

OPTIMIZATION AREA

Linear Programming I An introduction to the theory and methodology of linear programming.
I E 405, MATH 484, Q B A 451

Linear Programming II A further treatment of the theory and methodology of linear programming with emphasis on special formulations.
I E 505

Mathematical Programming I Introduction to optimization theory designed to provide the necessary fundamentals for nonlinear programming and more advanced studies in mathematical programming.
Q B A 452

Mathematical Programming II An in-depth treatment of nonlinear programming areas with emphasis on both theory and applications.
I E 510, I E 520, Q B A 540

Mathematical Programming III Recent advances in mathematical programming.
I E 521, MATH 510, MATH 555, Q B A 550

Dynamic Programming Study of the concepts underlying model building and optimization of dynamic systems, with applications to engineering, economic, and environmental systems.
I E 519, STAT 534

PROCESSES AREA

Inventory Models A study of inventory theory, deterministic and probabilistic models, single and multiproduct models in single- and multistage processes.
I E 508, OPMGT 518

Scheduling Models Scheduling models with simultaneous job arrival and probabilistic job arrival, network scheduling, and scheduling simulation techniques.
I E 507, I E 554, OPMGT 516

Queuing Models Theory of systems involving stochastic delay and stochastic service.
I E 509, I E 555

COMPUTATIONAL AND SIMULATION METHODS

Computational Methods
I E 513, I E 514, I E 551, CMPSC 453, CMPSC 454, CMPSC 551

Simulation Methods
I E 453, I E 522, Q B A 432, Q B A 532

OPERATIONS RESEARCH (O R)

590. Colloquium (1-3)

PETROLEUM AND NATURAL GAS ENGINEERING (PNG E)

TURGAY ERTEKIN, *Section Chair of Petroleum and Natural Gas Engineering*
102 Mineral Sciences Building
814-865-6082

Degrees Conferred: Ph.D., M.S.

Senior Member of the Graduate Faculty
Turgay Ertekin, Ph.D. (Penn State) *Professor of Petroleum and Natural Gas Engineering*

Associate Members of the Graduate Faculty
Jamal H. Abou-Kassem, Ph.D. (Calgary) *Assistant Professor of Petroleum and Natural Gas Engineering*
Michael A. Adewumi, Ph.D. (IIT) *Assistant Professor of Petroleum and Natural Gas Engineering*
Abraham S. Grader, Ph.D. (Stanford) *Assistant Professor of Petroleum and Natural Gas Engineering*
William C. Tosch, Ph.D. (Purdue) *Associate Professor of Petroleum and Natural Gas Engineering*

Areas of specialization include experimental and theoretical studies of water flooding and the newer methods for displacing oil from porous media, methods for calculating reservoir performance, scaled laboratory studies of reservoir phenomena, and drilling and well completion problems.

Admission Requirements

Scores from the Graduate Record Examination (GRE) are required for admission. A minimum combined GRE score of 1000 with a quantitative GRE score of 700 (minimum) is expected. At the discretion of the graduate committee of the program, a student may be admitted provisionally for graduate study without these scores. Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin*.

Students who expect to enter graduate study in this program with a degree in another major should present 6 credits in geology, 15 in engineering science, and credit for mathematics through integral calculus. A limited number of deficiencies may be made up after admission.

Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

Degree Requirements

Certain closely related courses outside the department may be counted as petroleum and natural gas credits toward the degree.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of one foreign language.

Other Relevant Information

Students in this program may elect the dual-title degree program option in Operations Research for the Ph.D. and M.S. degrees (see p. 326).

Student Aid

In addition to the fellowships, traineeships, graduate assistantships, and other forms of financial aid described in the STUDENT AID section of the *Graduate Bulletin*, some company fellowships have been available to graduate students in this program.

PETROLEUM AND NATURAL GAS (P N G)

405. Reservoir Engineering (3)
406. Rock and Fluid Laboratory (1)
410. Applied Reservoir Engineering (3)
420. Applied Reservoir Analysis (3)
425. Principles of Well Testing and Evaluation (3)
430. Reservoir Modeling (3)
440. Formation Evaluation (3)
450. Drilling Design and Production Engineering (3)
451. Oil Well Drilling Laboratory (1)
475. Petroleum Engineering Design (3)

480. Production Process Engineering (3)
481. Natural Gas and Gasoline Plants (2)
482. Production Engineering Laboratory (1)
485. Engineering in Secondary and Tertiary Recovery (3)
486. Tertiary Oil Recovery Methods (3)
493. Engineering Evaluation of Oil and Gas Properties (3)
494. Thesis (1-6)

501. Steady State Flow in Porous Media (3) The formulation and analytical solution of the problems of steady state fluid flow in porous media.

502. Unsteady Flow in Porous Media (3) The formulation and analytical solution of the transient fluid flow in porous media. Prerequisite: P N G 501.

503. Reservoir Engineering Problems (3) Identification, formulation, and solution of advanced problems in reservoir engineering, e.g., cross-flow problems, dual porosity problems, etc. Prerequisite: P N G 502.

511. Numerical Solution of the Partial Differential Equations of Flow in Porous Media (3) Differencing schemes for the partial differential equations of single-phase flow; application to flow of gas and mixing in porous media.

512. Numerical Reservoir Simulation (3) Mathematical analysis of complex reservoir behavior and combination drives; numerical methods for the solution of behavior equations; recent developments. Prerequisite: P N G 510.

513. Advanced Numerical Reservoir Simulation (3) Compositional simulation; history-matching theory; simulation of basic processes involving heat and mass transfer in porous media. Prerequisite: P N G 512.

514. Optimization of Petroleum Recovery Processes (3) Optimum search methods, linear programming, nonlinear programming, dynamic programming, application to water flooding, depletion drive, steam injection, gas cycling, miscible displacement. Prerequisite: P N G 410.

515. Advanced Oil Recovery Techniques (3) Advanced oil recovery techniques including water flooding, in situ combustion, steam injection, hot-water injection, and miscible-phase displacement.

518. Design of Miscible Recovery Projects (2) Theory and design of miscible methods of oil recovery, current field applications, including hydrocarbon, CO_2, micellar/polymer, alkaline, and inert gas. Prerequisite: P N G 485.

519. Design of Thermal Recovery Projects (3) Suitability of reservoirs for thermal oil recovery; case histories; design of in situ combustion and steamfloods; thermal stimulation; shale oil recovery. Prerequisite: P N G 515.

520. Phase Relations in Reservoir Engineering (3) Phase relations as applied to condensate and retrograde condensate reservoirs and to other problems in petroleum production.

530. Natural Gas Engineering (1-3) Flow in producing or storage reservoirs; gas well testing; transmission systems; storage cycle; current developments. Prerequisite: P N G 481.

550. Advanced Engineering Evaluation of Oil- and Gas-Producing Properties (3) Selected topics of current research and development interest in formation evaluation, geophysical well logging, and production economics. Prerequisites: P N G 440, 493.

555. Drilling Optimization (3) Procedures for optimizing fluid properties, hydraulics, bit weight and selection. Balanced drilling conditions are stressed.

575. Gas Lift Design and Optimization (3) Design of continuous and intermittent gas lift systems; multiphase flow and inflow well performance.

590. Colloquium (1-3)

596. Individual Studies (1-9)

597. Special Topics (1-9)

Note: *Courses in the use of X-ray diffraction, electron microscopy, and spectroscopy in petroleum and natural gas studies are listed under MATERIALS SCIENCE.*

PHARMACOLOGY (PHARM)

ELLIOT S. VESELL, *Chair of the Department*
The Milton S. Hershey Medical Center
Hershey, PA 17033
717-531-8285

Degrees Conferred: Ph.D., M.S.

Senior Members of the Graduate Faculty
Cheston M. Berlin, M.D. (Harvard) *Professor of Pediatrics and Pharmacology*
Melvin L. Billingsley, Ph.D. (George Washington) *Assistant Professor of Pharmacology*
Karl H. Beyer, Jr., Ph.D. (Wisconsin) *Adjunct Professor of Pharmacology*
John D. Connor, Ph.D. (Phila. Col. Pharmacy and Science) *Professor of Pharmacology*
Frank E. Greene, Ph.D. (Florida) *Associate Professor of Pharmacology*
Samson T. Jacob, Ph.D. (Agra) *Professor of Pharmacology*
Walter B. Severs, Ph.D. (Pittsburgh) *Professor of Pharmacology*
Elliot S. Vesell, M.D. (Harvard) *Evan Pugh Professor of Pharmacology, Genetics, and Medicine*

Associate Members of the Graduate Faculty
Roscoe M. Hersey, Ph.D. (Rochester) *Assistant Professor of Obstetrics/Gynecology and Pharmacology*
Dai K. Liu, Ph.D. (Alabama) *Associate Professor of Pharmacology*
Thomas A. Lloyd, Ph.D. (Harvard) *Associate Professor of Obstetrics/Gynecology and Pharmacology*
G. Thomas Passananti, Ph.D. (Penn State) *Assistant Professor of Pharmacology*
Joan Y. Summy-Long, Ph.D. (Penn State) *Associate Professor of Pharmacology*

The graduate studies program in Pharmacology is designed to give qualified students a combination of didactic instruction, informal direction, and laboratory experience that will enable them to obtain a firm foundation in the principles, methods, and contributions of pharmacology (defined broadly as the science of the multiple aspects of the interaction of chemical agents with biological systems). With this preparation, graduates of the program should be capable of designing and executing high-quality independent research, and of assuming positions of responsibility within the pharmacologic community.

The department offers studies in the general areas of drug metabolism, molecular pharmacology, endocrine pharmacology, neuropharmacology, cardiovascular-renal pharmacology, and clinical pharmacology. Primary emphasis is placed on the molecular mechanism by which drugs act in the body and by which the body transforms drugs.

Admission Requirements
Scores from the Graduate Record Examination (GRE) are required for admission. At the discretion of the graduate program, a student may be admitted provisionally for graduate study without these scores. Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin*.

A bachelor's degree reflecting a reasonable background in zoology or biology, mathematics, and chemistry is required. Reading knowledge of one or two foreign languages is recommended. Students with a minimum junior-senior average of 3.00 and with appropriate course backgrounds will be considered for admission. Two letters of recommendation, a curriculum vitae, and a description of career goals are required. Students are not usually accepted into the graduate program unless they are preparing for the doctoral degree.

Master's Degree Requirements
A minimum of 30 credits as specified by the Graduate School are required. Candidates must submit a thesis based on original laboratory observations. There are no communication or language requirements. A specified core curriculum includes the following courses: B CHEM 502, 505; PHSIO 520, 521; PHARM 501, 502, 571, 590. Candidates must defend their dissertations to the satisfaction of the graduate faculty (two-thirds favorable vote).

Doctoral Degree Requirements
Students will demonstrate skills in one of the following areas of communications: computer language, biostatistics, or a foreign language (usually French, German, or Russian). A specified core curriculum includes the following courses: B CHEM 502, 505; PHSIO 520, 521; PHARM 501, 502, 520, 571, 590, 596 (experience in three to six different laboratories). Students take for credit at least

two elective courses in specialized areas of pharmacology and are encouraged to elect courses given by other departments at The Milton S. Hershey Medical Center. As an independent exercise, doctoral candidates will prepare a formal grant proposal for faculty review.

Other Relevant Information

Each new graduate student is assigned an adviser *pro tem* who will serve as a general counselor. Master's candidates have three months from initial registration to form an agreement with a member of the graduate faculty who will supervise their laboratory work. Doctoral candidates can take as much as a year to form this agreement.

Student Aid

Graduate assistantships available to students in this program and other forms of student aid are described in the STUDENT AID section of the *Graduate Bulletin*.

PHARMACOLOGY (PHARM)

501. Pharmacology (4) Lectures, discussions, and laboratory study of the mechanism of drug action in biological systems.

502. Pharmacology (4) Continuation of PHARM 501.

505. Pharmacokinetics (2) Quantitation of the time courses of absorption, distribution, metabolism, and excretion of drugs in the intact organism. Prerequisite: PHARM 501 or 502 or 520.

510. Neural Substrates for Drug Action (1) Study of nerve function in specific brain regions especially relevant to drug action.

511. Molecular Mechanism of Action of Drugs (2) Series of lectures and informal discussions on the molecular mechanism of action of some drugs and their clinical applications. Prerequisite: B CHEM 502.

512. Clinical Pharmacology (2) Drug therapy of cardiovascular, renal, and neural diseases.

515. Human Genetics (2) Seminar-type presentations by students and staff on fundamental problems and current topics in human genetics.

518. (CMBIO 518) Eukaryotic Gene Regulation (2) Emphasis will be on the regulation of gene expression in higher organisms. Prerequisites: BCHEM 502, 503, 505; MICRO 503.

520. Principles of Drug Action (2) Detailed analysis of basic parameters governing drug actions.

540. Pharmacogenetics (2) Study of human responses to individual drugs.

541. (CMBIO 541) Cellular Communication (2) This course explores the cellular and molecular basis of signal generation and information transduction in cells. Prerequisites: BCHEM 502, 505, CMBIO 540.

550. (NEURO 550) Neuropharmacology (3) An in-depth discussion of the mechanism and pharmacokinetics of various neuroactive drugs. Prerequisite: NEURO 510 or PSIO 510.

571. Techniques in Pharmacological Research (2) Classes will be comprised of lectures by the faculty of the Department of Pharmacology, followed by working demonstrations of the techniques.

575. Development of New Drugs (2) The development and clinical application of new therapeutic agents, using one or more prototype drugs as examples. Prerequisites: PHARM 501, 502.

590. Colloquium (1-3)

596. Individual Studies (1-9)

597. Special Topics (1-9)

PHILOSOPHY (PHIL)

CARL G. VAUGHT, *Head of the Department*
246 Sparks Building
814-865-6397

Degrees Conferred: Ph.D., M.A.

Senior Members of the Graduate Faculty
Joseph C. Flay, Ph.D. (Southern California) *Professor of Philosophy*
Carl R. Hausman, Ph.D. (Northwestern) *Professor of Philosophy*
Salim Kemal, Ph.D. (Cambridge) *Associate Professor of Philosophy*
Roberta Kevelson, Ph.D. (Brown) *Professor of Philosophy*
Joseph J. Kockelmans, Ph.D. (Institute of Medieval Studies, Angelicum, Rome) *Professor of Philosophy*
Alphonso F. Lingis, Ph.D. (Louvain) *Professor of Philosophy*
Stanley H. Rosen, Ph.D. (Chicago) *Evan Pugh Professor of Philosophy*
Carl G. Vaught, Ph.D. (Yale) *Professor of Philosophy*

Associate Members of the Graduate Faculty
Robert S. Corrington, Ph.D. (Drew) *Assistant Professor of Philosophy*
Veronique M. Foti, Ph.D. (Boston College) *Assistant Professor of Philosophy*
Robert E. Ginsberg, Ph.D. (Pennsylvania) *Professor of Philosophy*
Emily R. Grosholz, Ph.D. (Yale) *Associate Professor of Philosophy*
Irene E. Harvey, Ph.D. (York) *Assistant Professor of Philosophy*
Dale Jacquette, Ph.D. (Brown) *Assistant Professor of Philosophy*
David R. Lachterman, Ph.D. (Penn State) *Associate Professor of Philosophy*
Robert G. Price, Ph.D. (Yale) *Associate Professor of Philosophy*
Albert G. Tsugawa, Ph.D. (Michigan) *Associate Professor of Philosophy*

A thorough grounding in the history of philosophy is desirable for all students. Specialization is possible in areas (such as aesthetics, metaphysics, ethics, social philosophy, logic, and history and philosophy of science); in movements of thought (such as rationalism, empiricism, idealism, phenomenology, and existentialism); or in any of the major figures in the history of Western philosophy. Specialization is also possible in a joint program with the Department of Mathematics in logic and the foundations of mathematics, and with the Department of Physics in philosophy of science.

Admission Requirements
Scores from the Graduate Record Examination (GRE), or from a comparable substitute examination accepted by a graduate program and authorized by the dean of the Graduate School, are required for admission. At the discretion of a graduate program, a student may be admitted provisionally for graduate study in a program without these scores. Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin.*

Undergraduate preparation to the extent of a strong minor is advisable.

Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

Degree Requirements
The department may waive the requirement of a thesis for an M.A. candidate. The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of two foreign languages or by comprehensive knowledge of one.

Student Aid
In addition to the fellowships, traineeships, graduate assistantships, and other forms of financial aid described in the STUDENT AID section of the *Graduate Bulletin,* the following awards typically have been available to graduate students in this program:

EDWIN ERLE SPARKS DISSERTATION FELLOWSHIP IN THE HUMANITIES — Available to a doctoral candidate in one of the following graduate programs: classics, comparative literature, English, French, German, history, linguistics, philosophy, religious studies, Slavic languages and literatures, Spanish, and speech communication; stipend $8,040 plus tuition. Apply to department before February 1.

Edwin Erle Sparks Fellowships in the Humanities (8) — Available to beginning graduate students in one of the following graduate programs: classics, comparative literature, English, French, German, history, linguistics, philosophy, religious studies, Slavic languages and literatures, Spanish, and speech communication; stipends $7,040 plus tuition. Apply to department before February 1.

PHILOSOPHY (PHIL)

403. Environmental Ethics (3)
408. Social and Political Philosophy (3)
413. Philosophy of Literature (3)
414. Aesthetics (3)
419. American Philosophy (3)
421. Philosophy of Science (3)
424. Philosophy of Religion (3)
425. Theory of Knowledge (3)
426. Metaphysics (3-6)
429. Philosophy of Language (3)
432. (S T S 432) Medical Ethics (3)
433. Ethics and the Engineer (3)
435. (S T S 435) The Interrelation of Science, Philosophy, and Religion (3)
440. (PH ED 440) Philosophy and Sport (3)
443. Philosophy of Mathematics (3)
449. Philosophical Logic (3)
450. Pre-Socratic Philosophy (3-6)
451. Plato (3-6)
452. Aristotle (3-6)
460. Studies in Medieval Philosophy (3)
470. Continental Rationalism (3-6)
471. British Empiricism (3-6)
472. Enlightenment Philosophy (3-6)
473. Vico (3-6)
474. Kant (3-6)
475. Fichte and Schelling (3-6)
476. Hegel (3-6)
480. Marx (3-6)
481. Nietzsche (3-6)
482. Peirce (3-6)
483. Cassirer (3-6)
484. Husserl (3-6)
485. Heidegger (3-6)
486. Wittgenstein (3-6)
487. Analytic Philosophy (3-6)
488. Contemporary French Philosophy (3-6)
489. (S T S 489) Technology and Human Values (3)
496. Independent Studies (1-18)
497. Special Topics (1-9)
499. Foreign Study — Philosophy (1-12)

500. Ethics: Historical and Systematic (3 per semester, maximum of 6) Critical study of some problem of ethical theory, or of some period of the history of ethics.

504. Social and Political Philosophy (3-6) Critical study of basic problems in their historical and functional setting.

509. Seminar in Contemporary Philosophy (3-6) Men and movements in twentieth-century philosophy.

512. Advanced Topics in Philosophy of Science (3-6) Crucial problems in the theory of science and scientific method.

513. (B A 513, PSY 513) Principles and Methods of Empirical Science (3) Scientific methodologies and their presuppositions, with special emphasis on behavioral and social sciences. Prerequisite: doctoral candidacy in BA/PSY or graduate status in PHIL.

514. Nineteenth-Century Philosophy (3-6) Study of a philosopher or philosophical movement of the nineteenth century.

516. Seminar in Aesthetics (3-6) Problems and theories in the nature of art.

526. Seminar in Metaphysics (3-6) Formulation and analysis of metaphysical problems in the various fields of philosophy.

543. First-Order Logic (3) Logical theory and metatheory for truth-functions, quantifiers, and identity.

550. Seminar in Plato (3 per semester, maximum of 6) Analysis of a major Platonic dialog.

551. Seminar in Aristotle (3 per semester, maximum of 6) Analysis of a major Aristotelian treatise.

560. Seminar in Medieval Philosophy (3 per semester, maximum of 6) Study of the works of a leading thinker in the Middle Ages, such as Augustine, Anselm, Aquinas, or Ockham.

570. Seminar in Continental Rationalism (3 per semester, maximum of 6) Topics in continental rationalism. At certain points, the interpretations will refer to the Latin and French originals.

571. Seminar in British Empiricism (3 per semester, maximum of 6) Seminar devoted to a major figure or topic in the British tradition from Bacon to Mill.

572. Seminar in Kant (3 per semester, maximum of 6) Aspects of Kant's philosophy. At certain points, the interpretations will refer to the German original.

573. Seminar in Hegel (3 per semester, maximum of 6) Study of some Hegelian text; relevant scholarship and criticism. At certain points, the interpretations will refer to the German original.

580. Phenomenology (3 per semester, maximum of 6) A critical study of one or more thinkers, ideas, or movements in modern phenomenology.

581. Hermeneutics (3 per semester, maximum of 6) Hermeneutic philosophy and aspects of its methodological significance for human studies, philology, history, sociology and psychology, and philosophy of science.

582. Contemporary European Philosophy (3 per semester, maximum of 6) Husserl's phenomenology and Heidegger's existence philosophy; structuralist and critical Marxism; Gadamer and hermeneutics; Derrida and metaphysical deconstruction.

583. Anglo-American Philosophy (3 per semester, maximum of 6) The methods of contemporary philosophical analysis. Readings from Russell, Quine, Wittgenstein, Austin, Strawson, and related writers.

590. Colloquium (1-3)

594. Research Technique (1) A course utilizing research sources and techniques relevant to philosophical studies. Taken in the first semester of graduate study.

596. Individual Studies (1-9)

597. Special Topics (1-9)

602. Supervised Experience in College Teaching (1-3 per semester, maximum of 6)

PHYSICS (PHYS)

GERALD A. SMITH, *Head of the Department*
104 Davey Laboratory
814-865-7533

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Senior Members of the Graduate Faculty
Gerhard R. Barsch, Dr.rer.nat. (Göttingen) *Professor of Physics*
Moses H. W. Chan, Ph.D. (Cornell) *Professor of Physics*
Milton W. Cole, Ph.D. (Chicago) *Professor of Physics*
Paul H. Cutler, Ph.D. (Penn State) *Professor of Physics*
T. Emanuel Feuchtwang, Ph.D. (Stanford) *Professor of Physics*
Gordon N. Fleming, Ph.D. (Pennsylvania) *Professor of Physics*
Daniel R. Frankl, Ph.D. (Columbia) *Professor of Physics*
Norman Freed, Ph.D. (Case Western Reserve) *Professor of Physics*
Roland H. Good, Jr., Ph.D. (Michigan) *Professor of Physics*
Reinhard Graetzer, Ph.D. (Wisconsin) *Associate Professor of Physics*
Howard Grotch, Ph.D. (Cornell) *Professor of Physics*
Heinz K. Henisch, Ph.D. (Reading) *Professor of Physics*
Roger M. Herman, Ph.D. (Yale) *Professor of Physics*
Emil Kazes, Ph.D. (Chicago) *Professor of Physics*
Bruce R. F. Kendall, Ph.D. (Western Australia) *Professor of Physics*
L. George Lang, Ph.D. (Carnegie Tech.) *Professor of Physics*
Jeffrey S. Lannin, Ph.D. (Stanford) *Professor of Physics*
A. Hamid Madjid, Dr.Sc.Nat. (Swiss Fed. Inst. of Tech.) *Associate Professor of Physics*
Julian D. Maynard, Ph.D. (Princeton) *Professor of Physics*
Robert D. McCammon, D.Phil. (Oxford) *Associate Professor of Physics*
T. King McCubbin, Jr., Ph.D., (Johns Hopkins) *Professor of Physics*
Benedict Y. Oh, Ph.D. (Wisconsin) *Associate Professor of Physics*
Don N. Page, Ph.D. (Cal. Tech.) *Professor of Physics*
Josef Pliva, Dr.Tech. (Technical, Prague) *Professor of Physics*
Santiago R. Polo, Ph.D. (Madrid) *Professor of Physics*
Peter B. Shaw, Ph.D. (Carnegie Tech.) *Associate Professor of Physics*
Gerald A. Smith, Ph.D. (Yale) *Professor of Physics*
Thomas T. Thwaites, Ph.D. (Rochester) *Associate Professor of Physics*
Tien-Tzou Tsong, Ph.D. (Penn State) *Professor of Physics*
Kuppuswamy Vedam, Ph.D. (Saugor) *Professor of Physics*
James J. Whitmore, Ph.D. (Illinois) *Professor of Physics*

Associate Members of the Graduate Faculty
Murat Gunaydin, Ph.D. (Yale) *Associate Professor of Physics*
Richard W. Robinett, Ph.D. (Minnesota) *Assistant Professor of Physics*

Graduate instruction and research opportunities are available in atomic and molecular physics, nonlinear optics, field emission and field ion microscopy, many aspects of solid-state and surface physics, low-temperature physics, ionosphere and vacuum physics, acoustics, physics of biological compounds, nuclear physics, experimental and theoretical particle physics, quantum field theory, and general relativity. Work in some areas is conducted in cooperation with the Materials Research Laboratory, the Ionosphere Research Laboratory, and the Applied Research Laboratory. Thesis research toward the applied M.S. degree and the applied option of the Ph.D. degree is usually carried out in one of these laboratories.

Admission Requirements
Scores from the Graduate Record Examination (GRE) are required for admission. Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin*.

A bachelor's degree in physics or an allied field is required for admission to the M.S., D.Ed., and Ph.D. programs. Students with a 2.50 or higher junior-senior average in physics and mathematics will be considered, and the best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests. Exceptions may also be made for applicants for doctoral programs who have completed master's degrees at other institutions.

Admission and study programs for the M.Ed. degree are handled on an individual basis.

Master's Degree Requirements

Standard M.S. program: Required courses include PHYS 525, 530, 532, 557, 559 (1 credit), 561 or 410. There are two options. Thesis option: The thesis must be based on at least 6 credits of PHYS 600 and must conform to Graduate School regulations. Nonthesis option: An additional 6 credits of 500-level Physics courses beyond the required ones must be taken, and a short paper must be submitted to, and accepted by, the department. There is no degree examination for either option.

M.S. program in applied physics: This program has prerequisites of junior/senior level courses in electricity and magnetism, mechanics, electronics, thermodynamics, optics, solid state physics, and computer programming. Required courses include advanced courses in electricity and magnetism and electronics, a 2-credit graduate laboratory course, a seminar series, and a course in quantum mechanics. In addition to these, two courses must be chosen from the areas of semiconductors, vacuum and electron physics, advanced optics, and acoustics; and at least two courses in the areas of properties of materials, space science, metallurgy, polymers, energy conservation, plasmas or fuel science, and atomic or molecular physics. Thesis research will start no later than the second semester and will be reported in a conventional master's thesis.

M.Ed. program: At least 18 credits in physics are required, of which up to 6 credits may be for research. Six additional nonresearch science credits (which may be in physics) and a 6-credit minor in a field of professional education also must be included. A thesis or term paper must be submitted and accepted by the department.

Doctoral Degree Requirements

Ph.D. program: Required courses include PHYS 517, 525, 530, 532, 557, 558, 559 (1 credit), 561, 562, and a first-year seminar series. Courses required beyond these depend on the Ph.D. option. Those who choose the standard option take at least four additional 3-credit, 500-level physics courses. Those who choose the applied physics option take at least four additional courses of an applied nature selected from a list which will be provided by the physics department on request.

A candidacy examination is given at the end of the first year, a comprehensive examination approximately two years after the candidacy examination, and a final thesis defense takes place after the completion of the thesis. There is no departmental foreign language requirement although a reading knowledge of one foreign language may be needed in some areas of research.

D.Ed. program: The requirements and procedures are the same as those for the Ph.D. program except for the following changes. Only two 500-level physics courses are required after the first ten courses listed above. An educational minor of at least 15 credits is required. A total of 90 credits must be earned in graduate school, at least 30 in residence. The thesis must be based on a minimum of 15 research credits.

Student Aid

In addition to the fellowships, traineeships, graduate assistantships, and other forms of financial aid described in the STUDENT AID section of the *Graduate Bulletin,* the following awards typically have been available to graduate students in this program:

Homer F. Braddock Graduate Fellowships — Available to exceptional Ph.D. candidates in several departments of the College of Science. They carry stipends of up to $7,500 per year for each of the first three years.

Wheeler P. Davey Memorial Fellowships — Carry a variable stipend and are available to a limited number of graduate students in physics.

David C. Duncan Graduate Fellowships — Available to first- and second-year graduate students in physics and carry a stipend of approximately $2,000 per year for each of the first two years.

PHYSICS (PHYS)

400. Intermediate Electricity and Magnetism (4)
402. Electronics for Scientists (4)
406. Nuclear Physics (3)
410. Introduction to Quantum Mechanics (3)
412. Solid State Physics I (3)
413. Solid State Physics II (3)
419. (MATH 419) Theoretical Mechanics (3)
420. Thermodynamics (3)
421. Kinetic Theory and Statistical Mechanics (3)

443. Intermediate Acoustics (3)
454. Atomic and Nuclear Physics (3)
457. Experimental Physics (1-2 per semester)
458. Intermediate Optics (4)
461. (MATH 461) Theoretical Mechanics (3)
467. Intermediate Electricity and Magnetism (3)
471. Quantum Theory of Atoms and Molecules (3)
496. Independent Studies (1-18)
497. Special Topics (1-9)

510. General Relativity (3) Foundations of general relativity; physics of metric spaces, tensor calculus; particle dynamics. Applications to stellar structure and cosmology. Prerequisites: PHYS 530; PHYS 525 or MATH 523.

511. Applications of General Relativity (3) Einstein's equations; empty and matter-filled spaces; conservation laws; Schwarzschild, Nordström-Reissner, and Kerr solutions; solar system tests; gravitational waves. Prerequisite: PHYS 510.

512. Introduction to the Quantum Theory of Solids I (3) Energy band theory; electrical, optical, and magnetic properties; lattice dynamics; transport theory. Prerequisite: PHYS 412. Concurrent: PHYS 517.

513. Introduction to the Quantum Theory of Solids II (3) Energy band theory; electrical, optical, and magnetic properties; lattice dynamics; transport theory. Prerequisite: PHYS 512.

517. Statistical Mechanics (3) Classical and quantum statistics; statistical thermodynamics; the Boltzmann transport equation; methods illustrated with applications to physical problems. Prerequisites: PHYS 420, 561.

518. Advanced Topics in Thermodynamics and Statistical Mechanics (3) Selected topics related to nonequilibrium thermodynamics, many-body problem, fluctuations, and statistical theory of random processes. Prerequisite: PHYS 517.

524. Physics of Semiconductors (3) Band structures, theory of electron and hole conduction, transport properties, excess carrier distributions, p-n junctions, metal-semiconductor contacts, semiconductor surfaces. Prerequisite: PHYS 412.

525. Methods of Theoretical Physics (3) Calculus of variations, ordinary differential equations, complex variables, numerical methods as applied to problems in theoretical physics.

530. Theoretical Mechanics (3) Newtonian mechanics, noninertial coordinate system, Lagrangian mechanics, small oscillations, rigid body motion, Hamiltonian mechanics.

532. Theoretical Continuum Mechanics (3) Wave phenomena, hydrodynamics, heat conduction, elastic continua. Prerequisite: PHYS 530.

533. Theoretical Acoustics (3) Vibrating systems; transmission of disturbances through elastic and viscoelastic media. Prerequisite: PHYS 530.

537. Vacuum Physics (3) An introduction to physical phenomena occurring at low pressures and their applications to the production and measurement of high vacuum.

541. Elementary Particle Phenomenology (3) Baryons, mesons, quarks; electromagnetic and weak interactions; charm and beauty; unification of weak and electromagnetic interactions; quantum chromodynamics; grand unification. Prerequisite: PHYS 562.

550. Applied Group Theory (3) Representations of discrete and continuous groups, applications to theoretical physics and differential equations, varying emphasis on the specific applications. Prerequisite: PHYS 525.

554. Nuclear Physics (3) Theory of nuclear structure and nuclear reactions; intermediate-energy nuclear theory; pion physics. Prerequisite: PHYS 562.

557. Electricity and Magnetism (3) Electro- and magnetostatics, Maxwell's equations, boundary value problems, electric band magnetic properties of material media.

558. Advanced Electricity and Magnetism (3) Energy and momentum in the field, radiation theory, classical relativistic electron theory. Prerequisite: PHYS 557.

559. Graduate Laboratory (1) Introduction to techniques and instrumentation used in modern physics, laboratories. Includes experience in planning experiments and working in research laboratories.

561-562. Quantum Mechanics (3 each) The basic theory of wave and matrix mechanics, approximation methods, applications. Prerequisite: PHYS 530.

563-564. Advanced Quantum Mechanics (3 each) Relativistic wave equations, quantum field theory, other advanced quantum theoretical topics. Prerequisite: PHYS 562.

571. Atomic Physics (3) Experimental basis of modern physics; atomic spectra and structure, nuclear phenomena.

572. Molecular Physics (3) Electronic and nuclear motions in molecules, molecular spectra and structure. Prerequisite: PHYS 571.

596. Individual Studies (1-9)

597. Special Topics (1-9) (e.g., surface physics, tunneling theory, field-ion microscopy, liquid helium, superconductivity, vacuum physics, ion optics, nonlinear optics, many-body theory.)

PHYSIOLOGY (PHSIO)

ELSWORTH R. BUSKIRK, *Chair of the Committee on Physiology*
119 Noll Laboratory
814-865-3453

Degrees Conferred: Ph.D., M.S.

Senior Members of the Graduate Faculty
Adam Anthony, Ph.D. (Chicago) *Professor of Zoology*
Craig R. Baumrucker, Ph.D. (Purdue) *Associate Professor of Animal Nutrition-Physiology*
Elsworth R. Buskirk, Ph.D. (Minnesota) *Professor of Applied Physiology*
Robert W. Christina, Ph.D. (Maryland) *Professor of Physical Education*
Robert J. Eberhart, Ph.D. (Penn State) *Professor of Veterinary Science*
Terry D. Etherton, Ph.D. (Minnesota) *Professor of Animal Nutrition*
Peter A. Farrell, Ph.D. (Arizona) *Associate Professor of Applied Physiology*
Edwin V. Gaffney, Ph.D. (Catholic) *Associate Professor of Microbiology and Cell Biology*
Roger P. Gaumond, Ph.D. (Washington) *Assistant Professor of Bioengineering*
Steven R. Goodman, Ph.D. (St. Louis) *Associate Professor of Physiology*
Michael H. Green, Ph.D. (California-Berkeley) *Associate Professor of Nutrition Science*
Daniel R. Hagen, Ph.D. (Illinois) *Associate Professor of Animal Science*
Timothy S. Harrison, M.D. (Johns Hopkins) *Professor of Surgery and Physiology*
Richard A. Hawkins, Ph.D. (Harvard) *Professor of Surgery and Physiology*
James L. Hodgson, Ph.D. (Minnesota) *Associate Professor of Applied Physiology*
Theodore M. Hollis, Ph.D. (Ohio State) *Professor of Biology*
Leonard S. Jefferson, Jr., Ph.D. (Vanderbilt) *Professor of Physiology*
Gary J. Killian, Ph.D. (Penn State) *Associate Professor of Animal Science*
Kathryn F. LaNoue, Ph.D. (Yale) *Professor of Physiology*
Roland M. Leach, Jr., Ph.D. (Cornell) *Professor of Poultry Science*
Magdi M. Mashaly, Ph.D. (Wisconsin) *Assistant Professor of Poultry Science*
Richard L. McCarl, Ph.D. (Penn State) *Professor of Biochemistry*
Glenn E. Mortimore, M.D. (Oregon) *Professor of Physiology*
Ralph O. Mumma, Ph.D. (Penn State) *Professor of Chemical Pesticides*
Anthony E. Pegg, Ph.D. (Cambridge) *Professor of Physiology*
Donald E. Rannels, Jr., Ph.D. (Penn State) *Associate Professor of Physiology*
Richard C. Rose, Ph.D. (Michigan State) *Professor of Physiology and Surgery*
Richard W. Scholz, Ph.D. (Purdue) *Professor of Veterinary Science*
Herbert S. Siegel, Ph.D. (Penn State) *Professor of Poultry Science*
Paul J. Wangsness, Ph.D. (Iowa State) *Professor of Animal Nutrition*
Carol F. Whitfield, Ph.D. (George Washington) *Associate Professor of Physiology*
E. W. Wickersham, Ph.D. (Wisconsin) *Associate Professor of Biology*
Jang-Yen Wu, Ph.D. (California-San Francisco) *Professor of Physiology*
Robert F. Zelis, M.D. (Chicago) *Professor of Medicine and Physiology*

Associate Members of the Graduate Faculty
Robert M. Bryon, Ph.D. (British Columbia) *Assistant Professor of Neurosurgery and Physiology*
Daniel R. Deaver, Ph.D. (West Virginia) *Assistant Professor of Animal Science*
Christine M. Gregg, Ph.D. (Michigan) *Assistant Professor of Biology*
W. Larry Kenney, Ph.D. (Penn State) *Assistant Professor of Applied Physiology*
Ronald S. Kensinger, Ph.D. (Florida) *Assistant Professor of Animal Nutrition and Physiology*
Chin-Tarng Lin, Ph.D. (Texas-Galveston) *Assistant Professor of Physiology*
Ralph Lydic, Ph.D. (Texas Tech) *Professor of Medicine and Physiology*
Louis F. Martin, M.D. (Brown) *Assistant Professor of Surgery and Physiology*
Robert B. Mitchell, Ph.D. (Penn State) *Associate Professor of Biology*
William H. Neff, Ph.D. (Penn State) *Associate Professor of Biology*
W. Channing Nicholas, M.D. (Pennsylvania) *Associate Professor of Applied Physiology*
Anton C. Schoolwerth, M.D. (Harvard) *Associate Professor of Medicine and Physiology*
Michael T. Snider, M.D., Ph.D. (Emory) *Professor of Anesthesia; Associate Professor of Physiology*
Robert F. Wideman, Jr., Ph.D. (Connecticut) *Assistant Professor of Poultry Science*
Regina Vasilatos Younken, Ph.D. (Penn State) *Assistant Professor of Poultry Science*

This is an intercollege program designed to enable students to obtain an integrated series of courses encompassing both the fundamentals of physiology and advanced training in a specialized area. Courses can be taken either at the Milton S. Hershey Medical Center or at University Park.

Graduate instruction in physiology is under the direction of a program committee composed of graduate faculty representing several departments or groups at University Park actively participating in the physiology program — including the areas of animal science, animal nutrition, biochemistry, bioengineering, biology, dairy science, microbiology, nutrition, physical education (exercise science), poultry science, and veterinary science — as well as the Department of Physiology at the Medical Center. The instructional staff is composed of faculty in those departments offering graduate courses in various areas of specialization in physiology. The program, including courses, laboratory experience, and original research, is designed for completion in three to four academic years.

Admission Requirements
Scores from the Graduate Record Examination (GRE) are required for admission. Scores from the Medical College Admission Test (MCAT) are required only for admission to the Milton S. Hershey Medical Center. At the discretion of a graduate program, a student may be admitted provisionally for graduate study in a program without these scores. Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin.*

Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

Degree Requirements
Deficiencies in chemistry, biological science, mathematics (through a second course in calculus), or physics must be made up early in the student's graduate program. All candidates (master's and doctoral) must complete a general basic laboratory course in physiology (combined cellular, mammalian, and comparative) before choosing an area of specialization. Possible areas of specialization are cardiovascular and respiratory physiology; cellular and subcellular physiology; comparative physiology; environmental physiology; exercise physiology; physiology of nutrition and metabolism; neurophysiology; renal physiology; and reproductive physiology. The graduate committee for majors shall be appropriately represented by members of the physiology program committee and those of the area of specialization who shall have the responsibility and jurisdiction for determining the course program and research acceptable in satisfying degree requirements. The nonthesis option is available for the M.S. degree on a limited basis.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by one of several options including intermediate knowledge of one foreign language.

Other Relevant Information
The following courses, among others, are available for physiology majors, and their descriptions may be found under the offerings of several departments: AGRO 512, 545; AN SC 420, 431, 510, 514, 515; A NTR 401, 501, 503; BIOCH 401, 402, 403, 417, 437, 514, 520, 525; BIOE 402, 501, 502, 503, 504, 505, 506, 507, 552, 553, 570; BIOL 409, 428, 429, 437, 465, 466, 467, 472, 473, 477, 479, 538, 539, 550; CMPSC 403, 412, 413; EDPSY 400, 406, 450, 506, 507; E E 405, 569; FD SC

521; HL ED 511, 513; MICRB 400, 401, 410, 412, 503, 506, 507; M C B 440, 476, 485; NUC E 405, 420; NUTR 452, 457, 458, 459, 552, 557, 558; PH ED 455, 456, 457, 480, 484, 530, 565, 567, 577, 580, 582, 584, 586, 587; PHYS 400, 402, 420; PTYSC 424, 455; PSY 402, 450, 456, 527; STAT 451, 460, 462, 464, 501, 502, 505; V SC 405, 418, 420, 525, 528, 550.

The following courses in anatomy and biochemistry are offered at The Milton S. Hershey Medical Center: ANAT 503, 505, 510, 512, 515, 530, 535, 542, 543, 544, 545, 550; BCHEM 502, 503, 505, 513, 523, 528, 551, 553; L A M 501, 503, 507, 510, 515; MICRO 552, 554, 555, 559; NEURO 509, 510, 515, 526, 527, 528, 550; PHARM 502, 505, 511, 515, 520, 540, 550. Descriptions of these courses can be found under the designated program.

Student Aid

In addition to the fellowships, traineeships, graduate assistantships, and other forms of financial aid described in the STUDENT AID section of the *Graduate Bulletin,* the following awards typically have been available to graduate students in this program:

National Institute of Aging Traineeships — Available to doctoral students in selected graduate programs for research training in adult development and aging; stipend varies. Details available from the Gerontology Center, S210 Henderson Building South.

Mrs. A. Robert Noll Graduate Fellowship in Applied Physiology — For graduate research in applied physiology, especially in environmental or exercise physiology; stipend variable.

PHYSIOLOGY (PSIO) (Hershey)

510. (NEURO 510) Neurobiology I (2) A general discussion of the cellular and molecular nature of the various aspects of neurophysiology.

520. Medical Physiology (2) Cellular physiology including membrane permeability, bioelectric potentials, muscular contractions, secretion; metabolic physiology, including control of metabolism by hormones.

521. Medical Physiology (4) Organ physiology; examination of respiratory, renal, gastrointestinal, and cardiovascular physiology.

523. Physiology Laboratory (2) Practical exercises in the areas of cardiovascular, respiratory, renal, and gastrointestinal physiology. Prerequisite: PSIO 520. Concurrent: PSIO 521.

525. General Physiology (2) Cellular processes of accumulation membrane transport, bioelectric potentials, contraction, and secretion in erythrocytes, nerves, sensory receptors, muscles, glands, excretory organs.

526. (NEURO 526) Molecular Neuroscience (2) An in-depth discussion of the molecular nature of various components of neurotransmission. Prerequisite: PSIO 510 or NEURO 510.

527. (NEURO 527) Neurobiology of the Visual System (2) This course provides an updated and detailed knowledge of the molecular and cellular mechanism of the visual processes. Prerequisite: PSIO 510 or NEURO 510.

530. (CMBIO 530) Metabolic and Endocrine Physiology (3) Regulation of carbohydrates, fatty acid, and protein metabolism; regulation of hormone secretion; effects of hormones on water and cell metabolism.

534. Heart and Skeletal Muscle (2) Discussion of structure, chemistry, and physiology of heart and skeletal muscle. Prerequisites: PSIO 520, 521.

536. Gastrointestinal Physiology (2) Mechanisms of absorption and secretion by stomach, intestine, pancreas, and gallbladder. Neural and hormonal regulation, bioelectric potentials, pathophysiology. Prerequisite: PSIO 521.

538. Pulmonary Physiology (2) Discussion of selected topics in pulmonary physiology emphasizing areas of current research in both respiratory and nonrespiratory lung functions. Prerequisites: PSIO 520, 521.

540. (CMBIO 540) Cell Biology (3) Lectures in cell biology, including membrane, cytoskeleton, and organelle structure and function; cell division, differentiation, adhesion, communication, and movement. Prerequisite: BCHEM 502.

590. Colloquium (1-3)

596. Individual Studies (1-9)

597. Special Topics (1-9)

PHYSIOLOGY (PHSIO) (University Park)

567. (EXSCI 567) Advanced Exercise Physiology (3) Physiological changes during exercise, with emphasis on the effects of physical conditioning and training. Prerequisites: BIOL 472, EXSCI 480.

571. (BIOL 571) Animal Physiology (3) Mammalian cardiovascular, respiratory, renal, and gastrointestinal systems. Prerequisite: BIOL 472.

572. (BIOL 572) Animal Physiology (3) Mammalian nervous, endocrine, metabolic, and reproductive systems. Prerequisite: BIOL 472, 473.

577. (EXSCI 577) Applied Cardiovascular Physiology (3) In-depth study of applied electrocardiography and cardiac physiology. Prerequisite: 4 credits in physiology at the 400 or 500 level.

580. (EXSCI 580) Analysis of Body Composition (2) Study of the methods employed in the analysis of body composition. Prerequisite: BIOL 472 or 3 credits in physiology at the 400 or 500 level.

585. (EXSCI 585) Applied Physiology: Thermal (3) Physiological mechanisms activated by exposure to environmental temperature. Prerequisite: EXSCI 480 or 3 credits in physiology at the 400 or 500 level.

586. (EXSCI 586) Research Methods in Applied Physiology (3) Historical and current procedures for evaluation of cardio-pulmonary function, metabolism, and thermal balance in humans; lecture, demonstration, and student laboratory. Prerequisite: 3 credits in physiology at the 400 or 500 level.

587. (EXSCI 587) Applied Physiology: Ambient Pressure (3) Physiological mechanisms activated by exposure to environmental pressure. Prerequisite: EXSCI 480 or 3 credits in physiology at the 400 or 500 level.

590. Colloquium (1-3)

595. (EXSCI 595) Internship in Exercise Physiology and Cardiac Rehabilitation (1-15) Clinical and related research aspects of exercise physiology and exercise prescription with respect to cardiac and cardiovascular rehabilitation. Prerequisites: EXSCI 456, 457, 480, PHSIO 571, 572, 590; completion of one year of graduate work.

596. Individual Studies (1-9)

597. Special Topics (1-9)

PLANT PATHOLOGY (PPATH)

HERBERT COLE, JR., *Head of the Department*
211 Buckhout Laboratory
814-865-7448

Degrees Conferred: Ph.D., M.S., M.Agr.

Senior Members of the Graduate Faculty
John E. Ayers, Ph.D. (Penn State) *Professor of Plant Pathology*
James R. Bloom, Ph.D. (Wisconsin) *Professor Emeritus of Plant Pathology*
John S. Boyle, Ph.D. (Wisconsin) *Professor Emeritus of Plant Pathology*
Herbert Cole, Jr., Ph.D. (Penn State) *Professor of Plant Pathology*
Donald D. Davis, Ph.D. (Penn State) *Professor of Plant Pathology*
Charles H. Kingsolver, Ph.D. (Iowa State) *Adjunct Professor of Plant Pathology*
Kenneth T. Leath, Ph.D. (Minnesota) *Adjunct Professor of Plant Pathology*
Felix L. Lukezic, Ph.D. (California) *Professor of Plant Pathology*

William Merrill, Ph.D. (Minnesota) *Professor of Plant Pathology*
Paul E. Nelson, Ph.D. (California) *Professor of Plant Pathology*
Richard R. Nelson, Ph.D. (Minnesota) *Evan Pugh Professor Emeritus of Plant Pathology*
John W. Oswald, Ph.D. (California) *Professor Emeritus of Plant Pathology*
Eva J. Pell, Ph.D. (Rutgers) *Professor of Plant Pathology*
Daniel J. Royse, Ph.D. (Illinois) *Associate Professor of Plant Pathology*
Richard D. Schein, Ph.D. (California) *Professor Emeritus of Plant Pathology*
Lee C. Schisler, Ph.D. (Penn State) *Professor of Plant Pathology*
Robert T. Sherwood, Ph.D. (Wisconsin) *Adjunct Professor of Plant Pathology*
John M. Skelly, Ph.D. (Penn State) *Professor of Plant Pathology*
T. A. Toussoun, Ph.D. (California) *Professor of Plant Pathology*
Paul J. Wuest, Ph.D. (Penn State) *Professor of Plant Pathology*

Associate Members of the Graduate Faculty
Barbara J. Christ, Ph.D. (Penn State) *Assistant Professor of Plant Pathology*
James A. Frank, Ph.D. (Illinois) *Adjunct Associate Professor of Plant Pathology*
Frederick E. Gildow, Ph.D. (Cornell) *Assistant Professor of Plant Pathology*
Kenneth D. Hickey, Ph.D. (Penn State) *Professor of Plant Pathology*
Alan A. MacNab, Ph.D. (Cornell) *Professor of Plant Pathology*
Walter F. O. Marasas, Ph.D. (Wisconsin) *Adjunct Professor of Plant Pathology and Veterinary Science*
Gary W. Moorman, Ph.D. (North Carolina State) *Assistant Professor of Plant Pathology*
Stanley P. Pennypacker, Ph.D. (Penn State) *Associate Professor of Plant Pathology*
Charles A. Powell, Ph.D. (Nebraska) *Adjunct Assistant Professor of Plant Pathology*
C. Peter Romaine, Ph.D. (Cornell) *Associate Professor of Plant Pathology*
Patricia L. Sanders, M.Ed. (Penn State) *Associate Professor of Plant Pathology*
James W. Travis, Ph.D. (North Carolina State) *Associate Professor of Plant Pathology*

Plant pathology is the study of disease in plants and concerns the dynamic interaction between the plant, the causal agent (bacteria, fungi, viruses, nematodes, etc.), and their environments. A student prepares for a professional career in research, teaching, extension, or industry through advanced studies of the principles of plant infection, the physiology of disease in plants, the ecology of root diseases, the nature and inheritance of disease resistance in plants, epidemiology, ecology and physiology of air pollution injury to plants, or plant disease control by biological or chemical means. A student also may specialize in the nature and control of the diseases of forest trees, agronomic or horticultural crops, and commercial mushrooms. Advanced studies in applied mycology, related to the production of the commercial mushroom, also may be taken. Modern, well-equipped laboratories, controlled environment facilities and greenhouses, and well-developed field research areas are available for graduate study.

Admission Requirements
Scores from the Graduate Record Examination (GRE), or from a comparable substitute examination accepted by a graduate program and authorized by the dean of the Graduate School, are required for admission. At the discretion of a graduate program, a student may be admitted provisionally for graduate study in a program without these scores. Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin.*

Students scoring in the 50th percentile or above on each section of the GRE will be given preference. The best-qualified applicants will be accepted up to the number of spaces and advisers that are available for new students. Students with a 2.80 junior-senior average and with appropriate course backgrounds will be considered for admission. Exceptions to the minimum 2.80 grade-point average may be made for students with special backgrounds, abilities, and interests.

For admission a student must present 42 credits in the sciences, including a minimum of 15 credits in mathematics, chemistry, or physics and a minimum of 15 credits, including a basic botany course, in the plant sciences. Students with a strong background in agronomy, biochemistry, biophysics, botany, forestry, genetics, horticulture, or microbiology are usually well prepared for advanced study in plant pathology.

Degree Requirements
Specific requirements for the M.S. and Ph.D. programs are available on request.

The Master of Agriculture degree is offered to provide professional training in plant pathology with more of a crop orientation than is available under the M.S. program. In addition to the courses required for an M.S. degree, the M.Agr. degree requires further study in the areas of entomology and crop sciences. A thesis substitute, such as an internship report, or an adaptive or demonstrative activity whereby known technology or procedures are applied, is acceptable.

Competency in a foreign language is not required for the Ph.D. degree. However, depending upon the nature of the thesis research and with the advice and consent of the doctoral advisory committee, competency in a foreign language may be judged to be an essential part of the doctoral studies of certain students.

Student Aid

Graduate assistantships available to students in this program and other forms of student aid are described in the STUDENT AID section of the *Graduate Bulletin*.

PLANT PATHOLOGY (PPATH)

401. Theory and Concepts of Plant Pathology (3)
402. Diseases of Economic Plants (2 per semester, maximum of 8)
403. Introduction to Epidemiology and Plant Disease Management (3)
404. Laboratory Techniques to Elucidate Principles of Plant Pathology (5)
406. Laboratory Techniques Emphasizing Phytopathogenic Bacteria, Viruses, and Fungi (1-3)
407. Laboratory Techniques of Phytopathology: Disease Occurrence and Control, Abiotic Stress, Nematology (1-3)
420. Plant Pathogenic Bacteria (3) *Lukezic*
422. Plant Virology (3) *Romaine*
424. Environmental Pathology (3) *Pell*
426. Plant Pathogenic Fungi (3)
429. Phytonematology (3)
444. (ENT 444) Biotechnology in Agriculture (2) *Romaine*
496. Independent Studies (1-18)
497. Special Topics (1-9)

502. Plant Disease Diagnosis (3) Field and laboratory techniques used in diagnosing plant diseases caused by various types of pathogens with emphasis on fungi. Prerequisites: PPATH 401, 404, 426. *Davis*

535. Principles of Plant Epidemiology (3) Analytical methodology useful in describing pest epidemics on crop populations and the application of this information for pest control. Prerequisites: AGRO 512, PPATH 401.

540. Plant Disease Control (3) Principles of plant disease control, including theoretical considerations involved in control by chemical and nonchemical means. *Cole*

541. Physiology of Plant Disease (3) Physiology of the diseased plant, including the host response to the pathogen and parasitic properties of the pathogen. *Lukezic*

542. Epidemiology of Plant Diseases (3) Disease development in populations of plants, with emphasis on the impact of environment and control practices on rate of development. Prerequisites: PPATH 401; MATH 111 or 141 or 3 credits in statistics. *Pennypacker*

543. Pathogen Variation and Host Resistance (3) Mechanisms and implications of genetic variation in plant pathogens related to breeding for disease resistance in plants by genetic means. Prerequisite: PPATH 401 or AGRO 411 or HORT 407. *Ayers*

544. Pathological Plant Anatomy (3) Structural manifestations occurring in diseased plants. Prerequisite: BIOL 407. *P. E. Nelson*

560. Principles of Plant Pathology (3) Open-ended discussions of concepts of plant pathology, with emphasis on their interrelationships and their significance to the science. *Lukezic*

590. Colloquium (1-3)

596. Individual Studies (1-9)

597. Special Topics (1-9)

602. Supervised Experience in College Teaching (1-3 per semester, maximum of 6)

PLANT PHYSIOLOGY (PLPHY)

JACK C. SHANNON, *Chair of the Graduate Program in Plant Physiology*
103 Tyson Building
814-863-2192

Degrees Conferred: Ph.D., M.S.

Senior Members of the Graduate Faculty
Richard N. Arteca, Ph.D. (Washington State) *Associate Professor of Horticultural Physiology*
Robert C. Baldwin, Ph.D. (Penn State) *Associate Professor of Wood Science and Technology*
Charles D. Boyer, Ph.D. (Penn State) *Professor of Plant Breeding and Genetics*
Steven L. Fales, Ph.D. (Purdue) *Associate Professor of Crop Management*
Paul J. Fritz, Ph.D. (Auburn) *Associate Professor of Food Science*
Robert H. Hamilton, Ph.D. (Michigan State) *Professor of Biology*
Ross C. Hardison, Ph.D. (Iowa) *Associate Professor of Biochemistry*
Charles W. Heuser, Ph.D. (Rutgers) *Associate Professor of Horticultural Physiology*
William A. Kendall, Ph.D. (Ohio State) *Adjunct Professor of Crop Physiology*
Daniel P. Knievel, Ph.D. (Wisconsin) *Associate Professor of Crop Physiology*
Felix L. Lukezic, Ph.D. (California) *Professor of Plant Pathology*
Ralph O. Mumma, Ph.D. (Penn State) *Professor of Chemical Pesticides*
John H. Pazur, Ph.D. (Iowa State) *Professor of Biochemistry*
Eva J. Pell, Ph.D. (Rutgers) *Professor of Plant Pathology*
Lee C. Schisler, Ph.D. (Penn State) *Professor of Plant Pathology*
Jack C. Shannon, Ph.D. (Illinois) *Professor of Plant Physiology*
Andrew G. Stephenson, Ph.D. (Michigan) *Professor of Biology*
S Edward Stevens, Ph.D. (Texas) *Professor of Microbiology and Molecular Biology*
Francis H. Witham, Ph.D. (Indiana) *Professor of Horticultural and Plant Physiology*

Associate Members of the Graduate Faculty
Marc D. Abrams, Ph.D. (Michigan State) *Assistant Professor of Forest Ecology and Physiology*
Donald A. Bryant, Ph.D. (California) *Associate Professor of Molecular and Cell Biology*
Daniel Cosgrove, Ph.D. (Stanford) *Associate Professor of Biology*
Roland R. Daniels, Ph.D. (Wisconsin) *Associate Professor of Horticulture*
George C. Elliott, Ph.D. (North Carolina State) *Assistant Professor of Floriculture*
Kathleen B. Evensen, Ph.D. (Florida) *Assistant Professor of Postharvest Physiology*
David L. Gustine, Ph.D. (Michigan State) *Adjunct Associate Professor of Crop Physiology*
Teh-Hui Kao, Ph.D. (Yale) *Assistant Professor of Molecular and Cell Biology*
Roger Koide, Ph.D. (California) *Assistant Professor of Biology*
Karen J. Miller, Ph.D. (Massachusetts) *Assistant Professor of Microbiology*
Christopher A. Mullin, Ph.D. (Cornell) *Assistant Professor of Entomology*
B. Tracy Nixon, Ph.D. (MIT) *Assistant Professor of Molecular and Cell Biology*
Jack C. Schultz, Ph.D. (Washington) *Assistant Professor of Entomology*

The intercollege program in Plant Physiology includes faculty from seven departments in the Colleges of Agriculture and Science. Each student becomes associated with the adviser's department, which may provide financial support, research facilities, and office space. Applicants are encouraged to explore opportunities by contacting faculty who may be prospective advisers.

The objective of this program is to educate and train plant physiologists for positions in industry, government, research institutes, and colleges and universities. Faculty in this program are competent to prepare candidates in almost all subfields of plant physiology including photosynthesis; photophysiology; translocation and assimilate partitioning; respiration; short distance solute transport and membrane physiology; organelle isolation and characterization; enzymology; synthesis and metabolism of carbohydrates, proteins, glycoproteins, and nucleic acids; phytohormone synthesis, breakdown, and action; mineral nutrition; nitrogen fixation; inorganic and organic nitrogen metabolism; plant genetic engineering and tissue culture; postharvest physiology; fruit and seed development, dormancy, and germination; stress and environmental physiology; host-pathogen relationships; and others.

Admission Requirements
Scores from the Graduate Record Examination (GRE) are required for admission. At the discretion of the graduate program officer, a student may be admitted provisionally for graduate study in a program without these scores. Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin*.

Students with a 3.00 junior-senior grade-point average and with appropriate course background will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces available for new students. Students entering this program should have had a strong foundation in the biological sciences, including biochemistry, general physics, and college mathematics through calculus. Students with limited deficiencies may be admitted but must make up deficiencies concurrently with their graduate studies. B.S.-level applicants with good academic records who have had strong training in plant physiology and related courses, including research experience, may be admitted directly into the Ph.D. program and bypass the M.S. degree.

Master's Degree Requirements

Candidates for the M.S. must take a written diagnostic examination during the first academic year in the program. The functions of this test are to (1) determine the areas of expertise and deficiency in the student's academic preparation and (2) serve as an early screening system to eliminate students with too great an academic deficiency to continue in the program.

All M.S. degree candidates will be required to complete BIOCH 401 and 402; 6 credits of advanced plant physiology (BIOL 511, 512); and 2 credits of colloquium (PLPHY 590). Upon recommendation of the advisory committee, equivalent courses taken at another university may be substituted for the above requirements. All M.S. candidates must complete a thesis, and at least 6 credits of thesis research (PLPHY 600 or 610) must be included in the program.

Doctoral Degree Requirements

Students in the Ph.D. program must successfully pass a written candidacy examination in addition to the oral candidacy, comprehensive, and final examinations required by the Graduate School. The functions of the written candidacy are the same as those of the diagnostic examination given the M.S. degree candidates. The written candidacy will be administered in the first year of a student's program.

Ph.D. candidates must complete the courses required for the M.S. plus an additional 3 to 4 credits of biochemistry technique (BIOCH 403 or 417); two individual studies courses (PLPHY 596) of at least 2 credits each with a plant physiology faculty member other than the major professor; and 1 credit of colloquium (PLPHY 590) each year in the program. Upon recommendation of the candidacy committee, equivalent courses taken at another university may be substituted for some of the above requirements. The communications and foreign language requirement may be met by demonstrating an intermediate knowledge of one foreign language, by completing at least 6 credits of course work, or by completing at least 6 credits in an area of English communications approved by the student's advisory committee. Other course requirements will be determined by the major professor and student's advisory committee based on the results of the candidacy examinations.

Other Relevant Information

The following courses, in addition to the required courses, are available for plant physiology majors, and their descriptions may be found under the offerings of several departments: AGRO 410, 438, 501, 512, 517, 518, 545; BIOCH 417, 425, 514, 520, 525; BIOL 407, 414, 418, 422, 426, 431, 432, 441, 442, 446, 465, 466, 506, 536, 538, 539, 540; CHEM 431, 439, 451, 452, 525, 526, 535, 536; FD SC 400, 410, 508, 509, 521; F P 413, 513; HORT 402, 412, 420, 421, 501, 506, 507, 520; MICRB 410, 476, 503, 507; M C B 440, 474; PPATH 444.

Student Aid

Graduate assistantships available to students in this program and other forms of student aid are described in the STUDENT AID section of the *Graduate Bulletin*. In most participating departments, Plant Physiology applicants are eligible for departmental teaching or research assistantships, and other assistantships supported by grant funds of individual faculty who make these award decisions.

PLANT PHYSIOLOGY (PLPHY)

590. Colloquium (1-4)
596. Individual Studies (1-9)

POLICY ANALYSIS (PANAL)

IRWIN FELLER, *Director, Graduate Program in Policy Analysis*
N254 Burrowes Building
814-865-0586

Degree Conferred: M.S. in Policy Analysis

Senior Members of the Graduate Faculty
William Boyd, Ph.D. (Chicago) *Professor of Education*
Irwin Feller, Ph.D. (Minnesota) *Professor of Economics*
Robert Friedman, Ph.D. (Illinois) *Professor of Political Science*
Larry Gamm, Ph.D. (Iowa) *Associate Professor of Health Administration and Planning*
Sheldon R. Gelman, Ph.D. (Brandeis) *Professor of Social Work*
Michael King, Ph.D. (Oregon) *Associate Professor of Political Science*
Thomas Larson, Ph.D. (Penn State) *Pennsylvania Professor of Government and Management*
Melvin Mark , Ph.D. (Northwestern) *Associate Professor of Psychology*
Kathryn Moore, Ph.D. (Wisconsin-Madison) *Professor of Education*
Jon Nelson, Ph.D. (Wisconsin-Madison) *Professor of Economics*
James Rodgers, Ph.D. (Virginia) *Professor of Economics*
Larry Spence, Ph.D. (California-Berkeley) *Associate Professor of Political Science*
John M. Stevens, Ph.D. (SUNY-Buffalo) *Associate Professor of Public Administration*
Marylee Taylor, Ph.D. (Harvard) *Associate Professor of Sociology*
Rex Warland, Ph.D. (Iowa State) *Professor of Rural Sociology*

Associate Members of the Graduate Faculty
David N. Allen, Ph.D. (Indiana) *Assistant Professor of Business Administration*
E. Allan Brawley, D.S.W. (Pennsylvania) *Professor of Social Work*
Anthony Cahill, Ph.D. (Pittsburgh) *Assistant Professor of Public Administration*
Timothy Considine, Ph.D. (Cornell) *Assistant Professor of Mineral Economics*
James Curtis, Ph.D. (Cornell) *Assistant Professor of Political Science*
James Fairweather, Ph.D. (Stanford) *Assistant Professor of Higher Education*
Emilia E. Martinez-Brawley, D.Ed. (Temple) *Professor of Social Work*

The graduate program in Policy Analysis is a multidisciplinary program that offers a graduate, professional education leading to the master of science (M.S.) in Policy Analysis.

The program prepares individuals for positions in policy analysis, program evaluation, research, policymaking, general administration, or consulting in the public, nonprofit, or private sectors. The program has been designed to provide a rigorous mainstream curriculum with core courses in analytical, methodological, and managerial skills and knowledge. The core courses are supplemented with electives and workshops in substantive policy fields. Students also have the opportunity to pursue specializations in several areas of interest such as economic growth, education, public management, and health policy.

Admission Requirements
Scores from the Graduate Record Examination (GRE), or from a comparable substitute examination accepted by a graduate program and authorized by the dean of the Graduate School, are required for admission. At the discretion of a graduate program, a student may be admitted provisionally for graduate study in the program without these scores. Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin*.

No single criterion will determine whether a candidate is accepted. Students are expected to have an undergraduate, junior-senior, grade-point average of 3.00 (on a 4.00 scale), scores from the Graduate Record Examination (GRE), two letters of reference, and a statement of intent or career objectives. The letters and statement should be forwarded directly to the graduate program in Policy Analysis. The best qualified applicants will be accepted up to the number of spaces available for new students. The M.S. degree program currently is available only to full-time students at the University Park Campus.

Degree Requirements
All candidates for the M.S. degree are required to complete successfully at least 27 credits of core courses and 9 credits of electives or workshops in addition to a master's essay.

Other Relevant Information

The curriculum consists of several specially designed courses in policy analysis, evaluation methodology, resource allocation, cost-benefit analysis, theories of social choice, and quantitative methods applied to policy analysis, in addition to courses that are cross-listed with political science, public administration, and economics. In addition, the elective and workshop sequence in the program is designed in conjunction with an adviser to meet specific student interests in selected subject areas or policy domains. The master's essay requirement may be completed in coordination with the workshop/elective sequence. The program also includes an internship option that may be exercised during the summer between the first and second year of the program. The objective of the internship is to provide a practical, challenging, and educational experience relevant to the student's interests or career objectives. Further, the program offers extensive, collaborative opportunities with other research centers and institutes at the University.

Student Aid

The graduate program in Policy Analysis offers several research assistantships in addition to the other forms of support or financial aid outlined in the STUDENT AID section of the *Graduate Bulletin*.

POLICY ANALYSIS (PANAL)

500. Introduction to Policy Analysis (3) Contemporary survey of major concepts and core elements of the development and process of policy analysis. Prerequisite: admission to M.S. program in policy analysis.

501. Evaluation and Policy Analysis (3) The use of research in policy-making processes, including issues of theory, methods, validity and relevance of inferences, and politics. Prerequisite: PANAL 500.

502. Resource Allocation (3) Application of microeconomics to problems of public sector resource allocation. Examines efficiency and equity conflicts, limited information, and uncertainty. Prerequisites: 6 credits in economics.

503. Cost-Benefit Analysis (3) Welfare economic foundations and techniques of cost-benefit analysis; treatment of conceptual, practical problems; application to specific public policies and programs. Prerequisite: PANAL 502.

504. Quantitative Methods in Policy Analysis I: Research Design, Measurement, Survey Methodology (3) Causal inference; experimental and quasi-experimental designs. Measurement; artifact; reliability and validity; scaling. Surveys: instrument construction; sampling; data collection; analysis. Prerequisite: 6 credits in statistics.

505. Quantitative Methods in Policy Analysis II: Applied Econometrics for Policy Analysis (3) Single and simultaneous equations, regression systems, econometric model building and diagnosis, structural analysis, time series, forecasting, and policy evaluation. Prerequisite: PANAL 504.

506. Theories of Social Choice (3) Normative implications of policy analysis.

577. (PUB A 577) Organization and Systems Management (3) Strategic and operational view of public organizations as systems; systems analysis and decision-making methods; project and operations management; case analysis.

586. (PL SC 586) Theory of Bureaucratic and Administrative Politics (3 per semester, maximum of 6) The role of the executive in government and politics; theories of administrative organization, organizational behavior, and the decision-making process.

595. Internship (1-9) Supervised internship in an agency or firm in which policy analysis is a primary focus.

596. Individual Studies (1-9)

597. Special Topics (1-9)

POLITICAL SCIENCE (PL SC)

TROND GILBERG, *Head of the Department*
112 Burrowes Building
814-865-7515

Degrees Conferred: Ph.D., M.A.

Senior Members of the Graduate Faculty
Henry S. Albinski, Ph.D. (Minnesota) *Professor of Political Science*
Vernon V. Aspaturian, Ph.D. (California-Los Angeles) *Evan Pugh Professor of Political Science*
Parris H. Chang, Ph.D. (Columbia) *Professor of Political Science*
James Eisenstein, Ph.D. (Yale) *Professor of Political Science*
Robert S. Friedman, Ph.D. (Illinois) *Professor of Political Science*
Trond Gilberg, Ph.D. (Wisconsin) *Professor of Political Science*
Robert E. Harkavy, Ph.D. (Yale) *Professor of Political Science*
Edward Keynes, Ph.D. (Wisconsin) *Professor of Political Science*
Michael R. King, Ph.D. (Oregon) *Associate Professor of Political Science*
Stanley A. Kochanek, Ph.D. (Pennsylvania) *Professor of Political Science*
John D. Martz III, Ph.D. (North Carolina) *Professor of Political Science*
Bruce A. Murphy, Ph.D. (Virginia) *Associate Professor of Political Science*
David J. Myers, Ph.D. (California-Los Angeles) *Associate Professor of Political Science*
Robert E. O'Connor, Ph.D. (North Carolina) *Associate Professor of Political Science*
Larry D. Spence, Ph.D. (California-Berkeley) *Associate Professor of Political Science*

Associate Members of the Graduate Faculty
Stephen J. Cimbala, Ph.D. (Wisconsin) *Associate Professor of Political Science*
James Curtis, Ph.D. (Cornell) *Assistant Professor of Political Science*
Nancy S. Love, Ph.D. (Cornell) *Assistant Professor of Political Science*

The purpose of the graduate program in Political Science is to train professional political scientists who intend to pursue careers in research, teaching, and public service. The department offers programs leading to the M.A. and Ph.D. degrees. The programs are designed to enable students to acquire both methodological sophistication and substantive knowledge in a variety of fields.

The graduate program in Political Science encourages the study of a variety of substantive concerns, methodological approaches, and research skills. Among the department's special areas of strength are the legislative and judicial processes; political parties and interest groups; administrative systems, urban politics; the politics and foreign policies of the Soviet Union, China, Latin America, South Asia, the British Commonwealth, and Eastern and Western Europe; international relations, law, and organizations; and a number of public policy areas. The department has a faculty of nineteen full-time members.

Admission Requirements

Scores from the Graduate Record Examination (GRE) verbal and quantitative tests are required for admission. Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin*.

Admission for either the M.A. or Ph.D. degree program also must include official transcripts, a statement indicating career plans and proposed emphasis in political science, and at least two letters of recommendation from academic personnel. These letters should be solicited from references familiar with the applicant's academic performance and should be mailed directly to the department. A total GRE score (verbal and quantitative) of 1150 is required. In exceptional cases, however, the Graduate Committee may waive the standing requirement.

Students with a 3.00 junior-senior average and appropriate course backgrounds, including at least the equivalent of 12 credits in political science, will be considered for admission.

Students can be admitted to the master's program or, after passing a Ph.D. candidacy exam, can be admitted to the Ph.D. program with a master's degree.

Entry into graduate work may occur in either the fall or spring semester, but completed applications must be on hand at least one month prior to planned entry.

Master's Degree Requirements

Depending on the student's previous methodological training, 30 to 33 credits of course work and a thesis or essay are required for a master's degree. The course work includes a methodological core of 6 to 9 credits in PL SC 409, 410 or their equivalents and PL SC 509; 12 credits in a primary field (in-

cluding a core course in the field); 6 credits in a secondary field; 6 credits for the M.A. thesis *or* an additional 6 credits in electives and a master's essay. There are no language requirements for the degree. Every master's candidate is required to pass a comprehensive examination.

Doctoral Degree Requirements

The communication and foreign language requirement for the Ph.D. may be satisfied by competence in approved skills selected from foreign languages, statistics, or mathematics and computer science.

Ph.D. students are required to take a core seminar in each of the five fields offered in the department: (1) American government and politics; (2) comparative politics; (3) international politics, organization, and law; (4) political theory and methodology; and (5) public administration.

In addition, each Ph.D. candidate is required to complete PL SC 509 (Scope and Methods) and PL SC 510 (Advanced Quantitative Political Analysis) for candidates in methodology.

Ph.D. degree candidates must present three fields for the purposes of comprehensive examinations; two fields selected from the five above; and a third field selected either from outside or within the department.

Other Relevant Information

The Department of Political Science has a successful faculty and student exchange program with the University of Kiel, West Germany.

The department offers a vigorous graduate program that provides students a number of opportunities to interact informally with faculty and other graduate students.

Student Aid

Graduate assistantships available to students in this program and other forms of student aid are described in the STUDENT AID section of the *Graduate Bulletin*.

POLITICAL SCIENCE (PL SC)

403. The Legislative Process (3) *Keynes and King*
405. The American Presidency (3) *Murphy*
409. Quantitative Political Analysis (3) *King and Kordesh*
410. Introduction to Political Research (3) *King and O'Connor*
412. International Economic Politics (3) *Golich and Harkavy*
413. Government and Politics of the Soviet Union (3) *Aspaturian and Gilberg*
414. Foreign Policy of the Soviet Union (3) *Aspaturian*
415. International Organization: Political and Security Functions (3-6) *Aspaturian, Golich, and Harkavy*
416. International Law (3)
417. American Local Government and Administration (3) *Friedman and O'Connor*
418. International Relations Theory (3)
419. (PUB A 419) Bureaucracy and Public Policy (3) *Friedman, Kordesh, and Spence*
420. Policy Making and Evaluation (3) *Curtis and Kordesh*
422. Comparative Urban Politics (3) *Gilberg and Myers*
425. Government and Politics of the American States (3) *Friedman and O'Connor*
427. Political Opinion (3) *O'Connor*
430. Selected Works in the History of Political Theory (3) *Curtis, Love, and Spence*
431. Ancient, Medieval, and Renaissance Political Theories (4) *Spence*
432. Modern and Contemporary Political Theories (4) *Curtis, Love, and Spence*
435. Foundations of American Political Theory (3) *Curtis and Spence*
436. Studies in Nineteenth- and Twentieth-Century American Political Thought (3) *Love and Spence*
438. National Security Policies (3) *Golich and Myers*
439. The Politics of Terrorism (3)
442. American Foreign Policy (3) *Harkavy*
443. American Security Problems (3) *Chang and Harkavy*
444. Government and the Economy (3) *Friedman and Kordesh*
446. The American Legal Process (3) *Eisenstein, Keynes, and Murphy*
447. Constitutional Law: The Federal System (3) *Keynes and Murphy*
448. Constitutional Law: Defendant's Rights (3) *Keynes and Murphy*
449. Constitutional Law: Individual and Minority Rights (3) *Keynes and Murphy*
450. Canadian and Australian Politics and Foreign Policies (3) *Albinski*
451. Comparative Political Analysis (3) *Albinski and Martz*

452. Governments and Politics of Eastern Europe (3) *Gilberg*
453. Political Processes in Underdeveloped Systems (3-6) *Chang, Kochanek, and Myers*
454. Government and Politics of Africa (3)
455. Governments and Politics of Western Europe (3) *Gilberg*
456. Politics and Institutions of Latin-American Nations (3) *Martz and Myers*
457. International Politics of Latin America (3-6) *Martz and Myers*
458. Government and Politics of East Asia (3-6) *Chang*
459. Government, Politics, and International Relations of South Asia (3) *Kochanek*
460. (S T S 460) Science and Public Policy (3) *Spence*
462. Marxist and Socialist Political Theory (3) *Love and Spence*
466. Comparative Foreign Policies of Western Europe (3)
467. International Relations of the Middle East (3) *Harkavy*
468. International Relations of East Asia (3) *Chang*
495. Political Science Internship (1-9)
496. Independent Studies (1-18)
497. Special Topics (1-9)
499. Foreign Study — Government (2-6)

500. Political Power (3-6) Subject announced prior to semester offered.

507. American Government Proseminar (3) Review of basic literature in major fields of American government: public opinion parties, voting, interest groups, presidency, congress, judiciary, etc. *Eisenstein*

509. Scope and Method of Political Science (3-6) *King, Martz, and O'Connor*

510. Advanced Quantitative Political Analysis (3) Analysis of selected issues in quantitative political analysis; introduction to advanced multivariate analysis techniques. Prerequisite: PL SC 409. *King*

512. Comparative Political Systems (3-9) *Albinski, Chang, Kochanek, and Myers*

513. Seminar in Comparative Political Parties (3-6) Nature, function, organization, and leadership of parties; party systems, political culture, voting, and the institutional framework. *Albinski and King*

515. International Politics (3-6) *Harkavy*

516. Seminar in International Relations Theory and Methodology (3) A detailed analysis of major traditional and contemporary theory-building efforts and contemporary research techniques and orientations in international relations. *Harkavy*

518. The Political Process in Latin America (3) Examination of the theory and practice of political processes in Latin America. Analysis of conceptual literature and contemporary political dynamics. Prerequisite: PL SC 453 or 456 or 457.

521. Modern Democratic Political Theory (3-6) *Love, Curtis, and Spence*

522. Seminar in the History of Political Theory (3) Analysis of selected political theorists or historical traditions of political thought. *Love, Curtis, and Spence*

523. Soviet Political Behavior (3) Forces which shape rivalries for power; decision-making processes; areas of agreement and dissent. *Aspaturian and Gilberg*

524. Foreign Policies of the Soviet Bloc (3-6) Major policies, the decision-making process, and the impact upon component members and external rivals for power. *Aspaturian and Gilberg*

525. Comparative American State and Local Politics (3-6) Literature and research in comparative state and local political systems in the United States. *Friedman and O'Connor*

526. Mass Politics and Public Opinion (3) Literature and research in mass politics and public opinion in the United States. *O'Connor*

529. (PUB A 529) Intergovernmental Relations (3) Overview of governmental agency and organizational relations across and within federal, state, substate, and local jurisdictional boundaries. *Friedman and Keynes*

530. Public Law (3-6) The nature of law and its role in modern society. *Eisenstein, Keynes, and Murphy*

532. Normative and Analytical Political Theory (3) Consideration of problems in contemporary theory construction. *Curtis, King, Love, and Spence*

546. Judicial Process (3) Court functions in the political process; sources and limits of judicial power; perceptions of the judicial role; judicial decision making. Prerequisites: 12 credits in political science. *Eisenstein and Keynes*

554. African Political Systems (3-6) Impact of European colonialism; cultural and anthropological factors in political development; modernization and analysis of selected problems in contemporary Africa. Prerequisite: 3 credits of comparative government or international relations at the 400 level.

572. (PUB A 572) International Development Administration (3-6) The examination of bilateral and multilateral development assistance programs; planning, implementation, and evaluation of development programs in LDCs. *LaPorte*

573. (PUB A 573) Comparative Public Administration (3-6) Administrative systems of selected nations on a functional basis; relationship between culture, economic and social systems, and public administration. *LaPorte and Myers*

574. (PUB A 574) Seminar in the Administration of United States Foreign Affairs (3) Effect of cross-cultural operations on the normal process of administration of United States foreign affairs. *LaPorte*

586. (PANAL 586) Theory of Bureaucratic and Administrative Politics (3 per semester, maximum of 6) The role of the executive in government and politics; theories of administrative organization, organizational behavior, and decision-making processes. *Friedman and Spence*

591. (PUB A 591) National Security Administration (3) National security system defense organization, decision making, and administration supply management; contract administration and procurement impact of defense expenditures.

594. Research in Political Science (1-6) Supervised student activities on research projects identified on an individual or small group basis.

595. Internship in Political Science (1-9) Supervised off-campus, nongroup instruction, including field experiences, practicums, or internships. Written and oral critique of activity required. Prerequisites: Prior consent of supervisor, adviser, or department head; applicable departmental internship requirements such as satisfactory completion of required upper-level courses appropriate for the internship program selected.

596. Individual Studies (1-9)

597. Special Topics (1-9)

POLYMER SCIENCE (PLMSC)

IAN R. HARRISON, *Program Chair*
BERNARD GORDON III, *In Charge of Graduate Program in Polymer Science*
325 Steidle Building
814-865-5972

Degrees Conferred: Ph.D., M.S.

Senior Members of the Graduate Faculty
David Allara, Ph.D. (UCLA) *Professor of Materials Science and Chemistry*
Michael M. Coleman, Ph.D. (Case Western Reserve) *Professor of Polymer Science*
Ian R. Harrison, Ph.D. (Case Western Reserve) *Professor of Polymer Science*
Paul C. Painter, Ph.D. (Case Western Reserve) *Professor of Polymer Science*
James P. Runt, Ph.D. (Penn State) *Associate Professor of Polymer Science*

Associate Members of the Graduate Faculty
John W. Gilmore, Ph.D. (Massachusetts) *Assistant Professor of Polymer Science*
Bernard Gordon III, Ph.D. (Arizona) *Associate Professor of Polymer Science*

The Polymer Science degree program is one of four areas in which a graduate student in the Department of Materials Science and Engineering may receive an advanced degree.

Polymer science is a multidisciplinary subject primarily concerned with the study of macromolecules (chain-like molecules of very high molecular weight). Polymeric materials are pervasive in today's technological society and find numerous applications in such diverse fields as plastics, elastomers (rubber), adhesives, surface coatings (paints), textiles, paper, packaging, and composites. Research facilities are available for studies involving the synthesis, chemical and physical characterization, and mechanical properties of polymeric materials. Special instrumentation exists for research in the areas of vibrational spectroscopy, thermal analysis, X-ray, size-exclusion chromatography, and mechanical testing.

Graduates with advanced degrees in Polymer Science are prepared for research and development careers in numerous academic, industrial, and government organizations involved with polymeric materials.

Admission Requirements

Scores from the Graduate Record Examination (GRE) or from a comparable substitute examination accepted by a graduate program and authorized by the dean of the Graduate School, are required for admission. At the discretion of a graduate program, a student may be admitted provisionally for graduate study in the program without these scores. Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin.*

Applications will be accepted from those having degrees in the basic or applied physical sciences or in engineering disciplines. Students with a 3.00 junior-senior average normally will be considered for admission. Exceptions may be made for students with special abilities, interests, or backgrounds, such as extensive industrial experience in polymer science.

A student entering the program with a B.S. degree normally will be expected to complete an M.S. thesis before continuing to the Ph.D. degree.

Master's Degree Requirements

There are no additional credit requirements beyond the Graduate School minimum of 30 credits, although most graduate students in the program will exceed this minimum. A nonthesis option for the M.S. degree is available in which a master's paper is required rather than a thesis. However, a student taking this option cannot continue toward a Ph.D. degree in the program. Competency in a foreign language is not required for the M.S. degree, but candidates are expected to demonstrate high proficiency in both written and spoken English.

Course work required for the M.S. degree will depend on the individual candidate's specific background and will be decided upon in consultation with the faculty members on the student's study panel. In general, the student will be required to take those courses deemed necessary to ensure a fundamental understanding of polymer science.

A candidacy examination will be administered during the M.S. defense for students enrolled in the M.S. thesis degree program. A decision concerning Ph.D. candidacy is made upon completion of this examination.

Doctoral Degree Requirements

Competency in a foreign language is not required for the Ph.D. degree, but candidates will be expected to demonstrate high proficiency in both written and spoken English. In addition, candidates will be expected to become familiar with the basics of a computer language.

There are no specific course work requirements for the Ph.D. degree, but candidates will be expected to have a thorough understanding of the basics of polymer science.

Students entering with an M.S. degree must pass a candidacy examination. This examination will be administered during the second semester. A typewritten technical paper of fifteen to thirty pages in length, the subject of which is decided upon by the student's study panel, must be submitted to the faculty members of the study panel at least one week prior to an oral examination. A decision concerning Ph.D. candidacy is made upon completion of this examination.

An oral comprehensive examination will be administered by the student's doctoral committee upon completion of the majority of the candidate's formal course work. The candidate will submit a brief written summary of his or her research topic to the members of the doctoral committee at least three days prior to the examination. At the oral examination, the candidate will present a seminar on his or her research topic and will be questioned by the doctoral committee on this topic and any other aspect in the overall field of polymer science. A decision concerning the comprehensive examination will then be made by the faculty members on the doctoral committee.

Other Relevant Information
The Polymer Science faculty consider that a good professional relationship between the faculty and graduate students is essential for graduate studies. Accordingly, graduate students are encouraged to interact with the faculty, and the faculty maintains an "open-door" policy.

Student Aid
In addition to the fellowships, traineeships, graduate assistantships, and other forms of financial aid described in the STUDENT AID section of the *Graduate Bulletin,* awards from various industrial sponsors typically have been available to graduate students in this program.

POLYMER SCIENCE (PLMSC)

400. Polymeric Materials (3)
403. Field Trip (1)
406. Introduction to the Materials Science of Polymers (3)
407. Polymer Science I (3)
409. Polymer Science II (3)
410. Mechanical Properties of Polymers and Composites (3)
412. Polymeric Materials Laboratory — Synthesis (2)
413. Polymeric Materials Laboratory — Characterization (2)
430. Natural Polymers (2)
490. Polymer Science Seminar (1)
496. Independent Studies (1-18)
497. Special Topics (1-9)

500. Advanced Polymeric Materials (3) In-depth discussions on the synthesis and properties of both novel and industrially significant polymers. Prerequisite: PLMSC 400.

510. Multicomponent Polymer Systems (3) A study of multicomponent polymer systems, including compatible and incompatible blends, interpenetrating networks, and reinforced elastomers and plastics. Prerequisite: PLMSC 406.

511. Scattering Techniques Applied to Polymers (3) A study of scattering techniques as applied to polymers, including discrete and diffuse small-angle X-ray and light scattering. Prerequisite: PHYS 203.

520. Crystalline Polymers (3) Morphology, characterization, and properties of crystalline polymers, including polymer crystals. Advanced characterization techniques as applied to crystalline polymers. Prerequisite: PLMSC 407 or 409.

521. Polymer Vibrational Spectroscopy (3) The theory and application of infrared and Raman spectroscopy as applied to polymeric materials, including elementary normal coordinate calculations. Prerequisites: MATH 231, PHYS 203.

562. Polymer Characterization Laboratory (2) Selected experiments in advanced characterization of polymeric materials. Prerequisite: PLMSC 406.

590. Colloquium (1-3)

596. Individual Studies (1-9)

597. Special Topics (1-9)

POULTRY SCIENCE (PTYSC)

HERBERT S. SIEGEL, *Head of the Department*
214 Animal Industries Building
814-865-3411

Degree Conferred: M.S.

Senior Members of the Graduate Faculty
Roland M. Leach, Jr., Ph.D. (Cornell) *Professor of Poultry Science*
Magdi M. Mashaly, Ph.D. (Wisconsin) *Associate Professor of Poultry Science*
Herbert S. Siegel, Ph.D. (Penn State) *Professor of Poultry Science*

Associate Members of the Graduate Faculty
Guy F. Barbato, Ph.D. (Virginia Polytechnic) *Assistant Professor of Poultry Science*
Christine M. Gregg, Ph.D. (Michigan) *Senior Research Associate*
William B. Roush, Ph.D. (Oregon State) *Assistant Professor of Poultry Science*
Regina Vasilatos-Younken, Ph.D. (Penn State) *Assistant Professor of Poultry Science*
Robert F. Wideman, Ph.D. (Connecticut) *Associate Professor of Poultry Science*

The department offers two types of degree programs: (1) an M.S. degree in poultry science, with one of the following major fields of interest: animal nutrition, genetics, management, or physiology; or (2) an M.S. or Ph.D. degree in one of the following disciplinary interdepartmental programs; animal nutrition, genetics, or physiology. In either case, direction of the student's program will be by a faculty member in the Department of Poultry Science.

Admission Requirements
Scores from the Graduate Record Examination (GRE), or from a comparable substitute examination accepted by a graduate program and authorized by the dean of the Graduate School, are required for admission. At the discretion of a graduate program, a student may be admitted provisionally for graduate study in a program without these scores. Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin.*

Admission requirements include 30 credits in the biological and physical sciences (chemistry, mathematics, and physics). Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

Master's Degree Requirements
Students with professional interests other than research may earn the M.S. in poultry science without doing a thesis; in this option, a paper on a selected professional problem is required for graduation.

Other Relevant Information
Students in the M.S. program may elect the dual-title degree program option in Operations Research (see p. 326).

Student Aid
Graduate assistantships available to students in this program and other forms of student aid are described in the STUDENT AID section of the *Graduate Bulletin.*

POULTRY SCIENCE (PTYSC)

405. Poultry Production Technology (3)
423. (AN SC 423) Applied Feeding of Swine, Poultry, and Laboratory Animals (1)
424. Applied Nutrition of Poultry and Laboratory Animals (1)
455. Animal Genetics (2)
495. Internship (8-10)
496. Independent Studies (1-18)
497. Special Topics (1-9)

502. Poultry Nutrition (2-4) *Leach*

582. (BIOL 582, PSY 582) Research in Animal Behavior (2-6 per semester) Research in special areas of animal behavior involving field or laboratory work. *Graves and Hall*

596. Individual Studies (1-9)

597. Special Topics (1-9)

Note: *See also ANIMAL SCIENCE.*

PSYCHOLOGY (PSY)

LYNN S. LIBEN, *Head of the Department*
417B Moore Building
814-865-9514

Degrees Conferred: Ph.D., M.S.

Senior Members of the Graduate Faculty
Karen L. Bierman, Ph.D. (Denver) *Associate Professor of Psychology*
Niels Birbaumer, Habil. (Munich) *Professor of Psychology*
Thomas D. Borkovec, Ph.D. (Illinois) *Professor of Psychology*
Paul R. Cornwell, Ph.D. (Michigan) *Professor of Psychology*
Keith A. Crnic, Ph.D. (Washington) *Associate Professor of Psychology*
Francis J. DiVesta, Ph.D. (Cornell) *Professor of Education and Psychology*
Juris G. Draguns, Ph.D. (Rochester) *Professor of Psychology*
James L. Farr, Ph.D. (Maryland) *Associate Professor of Psychology*
Leon Gorlow, Ph.D. (Columbia) *Professor of Psychology*
George M. Guthrie, Ph.D. (Minnesota) *Professor of Psychology*
Rick R. Jacobs, Ph.D. (California) *Associate Professor of Psychology*
Frank J. Landy, Ph.D. (Bowling Green) *Professor of Psychology*
Herschel W. Leibowitz, Ph.D. (Columbia) *Evan Pugh Professor of Psychology*
Lynn S. Liben, Ph.D. (Michigan) *Professor of Psychology*
Richard M. Lundy, Ph.D. (Ohio State) *Professor of Psychology*
Melvin M. Mark, Ph.D. (Northwestern) *Associate Professor of Psychology*
James E. Martin, Ph.D. (Illinois) *Associate Professor of Psychology*
Gerald E. McClearn, Ph.D. (Wisconsin) *Evan Pugh Professor of Health and Human Development and Psychology*
Harold E. Mitzel, Ph.D. (Minnesota) *Professor of Psychology and Education*
Keith E. Nelson, Ph.D. (Yale) *Professor of Psychology*
Merrill E. Noble, Ph.D. (Ohio State) *Professor of Psychology*
David S. Palermo, Ph.D. (Iowa) *Professor of Psychology*
Richard J. Ravizza, Ph.D. (Vanderbilt) *Associate Professor of Psychology*
William J. Ray, Ph.D. (Vanderbilt) *Professor of Psychology*
K. Warner Schaie, Ph.D. (Washington) *Evan Pugh Professor of Human Development and Psychology*
Robert Seibel, Ph.D. (Iowa) *Associate Professor of Psychology*
R. Lance Shotland, Ph.D. (Michigan State) *Professor of Psychology*
Robert M. Stern, Ph.D. (Indiana) *Professor of Psychology*
Hoben Thomas, Ph.D. (Claremont) *Professor of Psychology*
John M. Warren, Jr., Ph.D. (Wisconsin) *Professor of Psychology*
Walter B. Weimer, Ph.D. (Minnesota) *Adjunct Professor of Psychology*

Associate Members of the Graduate Faculty
William R. Balch, Ph.D. (Minnesota) *Associate Professor of Psychology*
David J. Brown, Ph.D. (Ohio State) *Adjunct Associate Professor of Psychology*
Frederick M. Brown, Ph.D. (Virginia) *Associate Professor of Psychology*
Richard A. Carlson, Ph.D. (Illinois) *Assistant Professor of Psychology*
Marion Gindes, Ph.D. (Columbia) *Adjunct Associate Professor of Psychology*
John A. Johnson, Ph.D. (Johns Hopkins) *Assistant Professor of Psychology*
Bennie Kathryn Mahoney, Ph.D. (Penn State) *Affiliate Assistant Professor of Psychology*
Margaret L. Signorella, Ph.D. (Penn State) *Assistant Professor of Psychology*
Valerie N. Stratton, Ph.D. (Penn State) *Assistant Professor of Psychology*

Graduate study in psychology is characterized by a highly individualized program leading to the Ph.D. degree. Emphasis is placed on research, teaching, and professional career development. Each

student is associated with one of the five program areas offered in the department: *Clinical* (including child clinical); *Developmental* (including both basic and applied developmental); *Experimental* (including cognitive studies, human performance, perception, physiological and comparative, psychophysiology, and human factors); *Industrial/Organizational;* and *Social.* An individual's particular pattern of interests dictates in part the course of study followed. Within all areas, research is an integral part of study; usually, the research is empirical in focus, but it may be applied or basic, depending on the problem of interest.

The department is located in a single building that contains laboratories, two VAX minicomputers, several microcomputer laboratories, darkroom, and shop. Students have access to the large resources of the University, which include an excellent computation facility and large open-stack library. Opportunities for practicum experience are available; e.g., clinical students find practicums in local mental health centers, while industrial students find placement in appropriate business or industrial settings.

Admission Requirements

Scores from the Graduate Record Examination (GRE) verbal and quantitative portions are required, and the Miller Analogies Test (MAT), if possible. All applicants should provide scores from the advanced psychology (subject) GRE test. Applicants with superior undergraduate (particularly junior and senior years) or graduate grade-point averages will be considered for admission. Although a major in psychology is not required, applicants should have a broad undergraduate background that includes 12 credits in psychology. Undergraduate study in psychology should include a course in statistics and a psychological methodology course. Requirements listed above are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin.*

Master's Degree Requirements

The psychology department does not have a graduate program designed for students seeking only the master's degree. The master's degree, or the department's equivalent, which is an acceptable published journal article, is required for advancement to candidacy for the Ph.D. degree in Psychology. Usually, but not always, the master's thesis centers on an empirical research topic. The typical thesis involves a literature review, data collection, analysis, and discussion. A master's degree is not awarded unless a thesis is submitted to the Graduate School.

Doctoral Degree Requirements

All students in their first year of residency must satisfactorily complete the department's English proficiency test.

Students must complete (within their first 60 graduate credits for students without previous graduate credit) 6 departmentally approved graduate credits in statistics with a grade of B or better. Additionally, students must complete, for graduate credit, departmentally approved courses in each of the following four areas: biological, cognitive, social and industrial, and individual differences psychology. Only a grade of B or better in each course satisfies the requirement, which must be completed prior to the time the doctoral comprehensive examination is taken. Students must complete 18 credits in a suitably selected major area; majors usually are defined by one of the five program areas noted above. The required minor may be satisfied in part by completing a Graduate School minor or by taking the appropriate 15 credits of course work within the department; in addition, students must complete an approved project. The Ph.D. comprehensive examination must be taken by the time 70 graduate credits are earned, or prior to the student's fourth year in residency, whichever comes first.

There is no departmental foreign language requirement.

A departmental doctoral option in Health Psychology is open to graduate students majoring in any area of psychology or related disciplines. Students admitted to the option will develop a course of study suited to their special interests. Each student will plan a course of study in consultation with the professor in charge and the student's doctoral adviser in the major field.

A minimum of 15 credits in health psychology must be taken in addition to any required by the major as follows: PSY 502 (3); PSY 503(3); 3 credits* from any course related to health psychology; and PSY 596* (0-6).

*To be approved by the professor-in-charge.

Other Relevant Information

The psychology department makes every effort to recruit and train minority psychologists. In 1969, the department unanimously adopted the ten-point plan of the Association of Black Psychologists. In the last ten years, many black students have been accepted into our program and have received the Ph.D. Support for minority students is coordinated by the department, the Graduate School Minority Graduate Scholars Award Program, and the American Psychological Association Minority Fellowship Program.

Student Aid

In addition to the fellowships, traineeships, graduate assistantships, and other forms of financial aid described in the STUDENT AID section of the *Graduate Bulletin*, the following awards typically have been available to graduate students in this program:

American Psychological Association Minority Program Fellowships — Students apply directly to the American Psychological Association; information is available from the Department of Psychology, 417 Moore Building.

PSYCHOLOGY (PSY)

401. Advanced Research Methods in Psychology (3)
402. Sensation and Perception (3)
404. Conditioning and Learning (3)
405. The Experimental Psychology of Visual Perception (3)
407. Behavior Genetics (3)
408. Comparative Psychology (3)
410. Historical Antecedents of Psychology (3)
411. Systems of Psychology and the Recent Past (3)
412. Abnormal Psychology (3)
414. Humanistic-Existential Psychology (3)
415. Intermediate Experimental Design (3)
417. Social Psychology (3)
419. Measurement and Decision Making (3)
420. (LING 420) Advanced Psycholinguistics (3)
421. Advanced Cognitive Psychology (3)
423. Cognitive Development (3)
424. Social and Personality Development (3)
425. Topics in Developmental Psychology (3)
426. Adolescence (2-3)
430. Psychology of Memory (3)
432. Introductory Engineering Psychology (3)
436. Mental Health in Schools (3)
437. Psychology of Adjustment (3)
438. Theory of Personality (3)
441. Industrial Motivation and Work Satisfaction (3)
444. Attention and Information Processing (3)
445. (I F S 445) Development Throughout Adulthood (3)
450. (EDPSY 450) Principles of Measurement (3)
451. Leadership in Work Settings (3)
456. Psychophysiology (3)
457. Experimental Social Psychology (4)
460. Learning and Memory (3)
461. Personnel Testing and Interviewing (3)
470. (I F S 470) Social Learning Foundations of Behavior Change (3)
471. The Psychology of Gender (3)
474. Psychology of Exceptional Children (3)
479. (RL ST 479) Religion and Culture in Freudian Thought (3)
481. Psychology of Industrial Relations (3)
482. Introduction to Clinical Psychology (3)
483. The Psychology of Fear and Stress (3)
484. Clinical Neuropsychology (3)
485. Developmental Biopsychology (3)
488. The Analytical Psychology of Carl Jung (3)

489. Psychology of Consciousness (3)
494. Senior Thesis (3-6)
495. Psychology Practicum (1-15)
496. Independent Studies (1-18)
497. Special Topics (1-9)

502. Overview of Health Psychology (3) Introduction to the role of psychology in maintaining health and in treating nonpsychiatric disorders.

503. Health Psychology Seminar (3) Seminars in specific areas in health psychology such as anxiety, biofeedback, pain, and stress. Prerequisite: PSY 502.

505. Research Problems in Psychology (1-15) Prerequisites: 12 credits in psychology.

510. History of the Higher Mental Processes (3) Stress upon theoretical, conceptual, and methodological problems involved in studying human thinking, language, memory, cognition, and other skills. Prerequisite: PSY 410 or 411.

511. Seminar in Contemporary Psychology (1-9) Critical review of readings on a topic of current interest, either in content or methodology, within psychology. Prerequisites: 9 credits in psychology.

513. (B A 513, PHIL 513) Principles and Methods of Empirical Science (3) Scientific methodologies and their presuppositions, with special emphasis on behavioral and social sciences.

515. Advanced Statistics in Psychology and Education (3) Correlation theory and methods; discriminant analysis, and factor analysis; applications to mental test theory. Prerequisite: PSY 415 or EDPSY 506.

517. Advanced Social Psychology (3) Problems of theory and of research methods with emphasis on persisting issues relevant to contemporary developments in social psychology. Prerequisites: PSY 417; PSY 015 or STAT 200.

520. (LING 520) Seminar in Psycholinguistics (3 per semester, maximum of 9) Consideration of theoretical and research issues relevant to psychological aspects of language sounds, syntax and semantics, and other cognitive support.

522. Personnel Selection and Appraisal (3) Evaluation of models for personnel selection, placement, and performance appraisal in business and industry. Prerequisites: PSY (EDPSY) 450, PSY 461.

523. Social-Organization Psychology in Industry (3) Analysis of the role of social and organizational variables as they affect employee performance and employee attitudes. Prerequisite: PSY 441.

526. (I F S 526) Measurement in Human Development (3) Principles and methods for assessment of human developmental processes across the life span. Prerequisites: EDPSY 450 or PSY 450; H DEV 516, I F S 519.

527. Statistical Inference and Experimental Design (3) Probability theory, sampling distributions, analysis of variance and covariance, analysis of trend, nonparametric statistics, experimental design. Prerequisite: PSY 415 or EDPSY 506.

529. (I F S 529) Seminar in Child Development (1-6) Readings and reports on recent findings in child development. Prerequisites: 6 graduate credits in child development, child psychology, or educational psychology, plus 3 in statistics.

531. Seminar in Performance Theory (3-9) Topics in theory and research on human performance in perceptual-motor and information-processing tasks. Prerequisite: PSY 432.

533. Advanced Engineering Psychology (3) Analysis of the role of the human operator in man-machine systems. Prerequisite: PSY 432.

534. Practicum in Industrial/Organizational Psychology (1-3) Supervised application of psychological principles in industrial and governmental settings. Prerequisites: PSY 441, 461.

535. Developmental Psychology (2-3) Developmental principles and concepts applied to psychological processes, with special reference to the experimental literature. Prerequisites: 9 credits in psychology.

536. (I F S 536) Research Methods in Developmental Processes (3) Methodological issues in research on varying stages of development across the individual life span. Prerequisites: 6 credits in individual development or psychology, and a course in statistics.

538. Psychology of Personnel Development (3) Industrial training in relation to psychological learning theory and experimental findings. Prerequisite: PSY 461 or EDPSY 421.

540. Seminar in Clinical Problems (1-9) Contemporary psychological theory, research, and methodology in relation to clinical psychology. Prerequisites: PSY 542, 560.

541. Personality Theory (3-4) Contemporary theories of personality; relevant research. Prerequisite: PSY 438.

542. Psychopathology (3-4) Theories of pathological behavior with reference to clinical and experimental data. Prerequisite: PSY 412.

543. Research Design in Clinical Psychology (3) Experimental and quasi-experimental designs, methodological problems, and techniques of experimental control in clinical psychology research. Prerequisite: 3 credits of statistics.

544. Psychological Hypnosis (3) Theory and research in psychological hypnosis. Techniques in the induction and clinical applications of hypnosis.

549. (I F S 549) Developmental Theory (3) Conceptual frameworks and major contributions to the study of individual development across the life span. Prerequisites: 6 credits at the 400 level in individual development or psychology.

555. Theory and Practicum in Clinical Assessment (3-9) Theoretical issues and research in clinical assessment with special reference to administration and interpretation of testing procedures and clinical interviewing. Prerequisites: PSY 541 or 542, and a course in measurement.

558. Clinical Child Psychology (3-9) Psychopathology of childhood; theories of etiology; diagnosis and treatment. Prerequisites: PSY 555, 561.

559. (S PSY 559) The Individual Psychological Examination (3) Demonstrations and practice in widely used ability and aptitude tests; psychological report writing. Prerequisites: 15 credits in psychology and a course in measurement.

560. Practicum in Clinical Methods (1-6) Supervised practice in the Psychology Clinic, including assessment, therapy, report writing, and staff participation. Prerequisite: PSY 555.

561. Clinical Practicum with Children (1-6) Diagnosis and counseling of child-parent problems of learning and adjustment. Prerequisites: PSY 425, 426, 555.

563. Behavior Modification I (3) Conceptual foundations of principles, assessment methods, and research strategies.

564. Behavior Modification II (3) Survey and empirical evaluation of treatment strategies. Prerequisite: PSY 563.

565. Seminar in Community Psychology (3) Application of social psychological research methods and principles to prevention and alleviation of behavior disorders in family and community settings.

566. Cultural Psychology (3) Experimental and descriptive research on culture and behavior in both Western and non-Western settings. Prerequisites: PSY 417, 438, and 6 credits in statistics.

569. Advanced Theory and Practicum in Counseling and Psychotherapy (3-9) Theoretical issues, research, and practicum experience in psychotherapy.

571. Seminar in Social Psychology (3-9) Historical development of theory and methods; determinants and principles of complex social or interactional behavior; contemporary problems and research.

580. Theory and Construction of Attitude Scales (3) Techniques for measuring attitudes and related intraindividual constructs; reliability and validity; attitude measurement procedures; multidimensional scaling; multiple indicator models. Prerequisite: 3 credits of 500-level statistics.

582. (BIOL 582, PTYSC 582) Research in Animal Behavior (2-6 per semester) Research in special areas of animal behavior involving field or laboratory work.

583. Designing Research in Social Psychology (3) Designs and procedures useful in social psychology and cognate disciplines; quasi-experimental designs and analysis, field experimentation, validity of inferences. Prerequisite: 3 credits of 500-level statistics.

584. (SOC 584) Attitude Formation and Change (3) Theory and method in research on attitude formation and change with emphasis on critical analysis. Prerequisites: PSY 417 or SOC 403; 3 credits in statistics.

585. (SOC 585) Interaction Processes Within and Between Groups (3) Interactions in personal, group, and intergroup relations; theory and observational methods. Prerequisite: PSY 417 or SOC 403.

586. (SOC 586) The Social Psychology of Social Change (3) The interaction of individual, social, and cultural determinants of group and individual change; emphasis on social movements, crowds, and audiences. Prerequisite: PSY 417 or SOC 403.

587. (SOC 587) Socialization (3) Behavioral, cognitive, developmental, symbolic, interactionist, and role theories of socialization; emphasis on current theory and research. Prerequisite: PSY 417 or SOC 403.

588. (SOC 588) The Social Organization of Attribution (3) Principles of attribution and their relevance to such topics as power relations, authority, equity, injustice, and social movements. Prerequisite: PSY 417 or SOC 403.

591. Seminar on Teaching Psychology (1-3) Objectives and content of psychology; organization and presentation of material; teaching aids and techniques.

596. Individual Studies (1-9)

597. Special Topics (1-9)

602. Supervised Experience in College Teaching (1-3 per semester, maximum of 6)

PSYCHOSOCIAL SCIENCE (PS SC)

JAMES R. HUDSON, *Coordinator*
Penn State Harrisburg, The Capital College
Middletown, PA 17057
717-948-6064

Degree Conferred: M.Ps.Sc. (Master of Psychosocial Science)

Senior Members of the Graduate Faculty
W. Glenn Clingempeel, Ph.D. (Virginia) *Associate Professor of Psychology*
James R. Hudson, Ph.D. (Michigan) *Associate Professor of Social Science and Sociology*
James F. Rooney, Ph.D. (Pennsylvania) *Associate Professor of Sociology*
Kathryn Towns, Ph.D. (Penn State) *Associate Professor of Educational Psychology*

Associate Members of the Graduate Faculty
Michael L. Barton, Ph.D. (Pennsylvania) *Associate Professor of Social Science and American Studies*
Thomas G. Bowers, Ph.D. (Virginia Polytechnic) *Assistant Professor of Psychology*
Eulalee Brand, Ph.D. (Temple) *Assistant Professor of Psychology*
Robert W. Colman, Ph.D. (North Carolina) *Assistant Professor of Social Science and Psychology*
Ida Marie Gentzler, M.Ps.Sc. (Penn State) *Instructor in Social Science*

The graduate program in Psychosocial Science, which is offered at Penn State Harrisburg, leads to a Master of Psychosocial Science degree, Community Psychology major. The program is designed to train students to develop innovative programs in communities and institutions with an emphasis on both course work and field experience. The program is concerned with equipping students with some of the skills necessary to cope with the multifaceted problems facing communities. Students should learn to recognize problems, to outline and implement possible solutions to these problems, and to evaluate the effectiveness of the solution.

To perform these functions the student must be aware of contemporary community needs, the impact of the community structure upon its individual members, and the techniques best suited to initiate productive changes. Course concentrations are available in human services management, coun-

seling skills, and individualized studies. After completing this interdisciplinary program, the graduate should be able to approach problems with a more integrated point of view and work cooperatively with community individuals and agencies toward practical solutions. Problems in drug abuse, delinquency, unemployment, housing, and other areas affecting mental health are approached from a community service agency base or from less formal community groups dealing with the same problems. At present approximately 90 percent of all students work full time in agencies or governmental units. To accommodate them, most graduate 500-level courses are scheduled in the evening, with a few given during the day.

Admission Requirements

Scores from the Graduate Record Examination (GRE) are not required for admission. Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin*.

For admission to the program, the grade-point average in the junior and senior years must be 2.50 or higher. Most applicants have degrees in psychology, sociology, or related disciplines. Students with other backgrounds may apply, particularly if they have had experience in community agencies. Students are expected to have taken a course in elementary statistics. Any deficiency in this area will be corrected without credit being applied to the degree requirements.

Off-campus and transfer credits will be evaluated by an admissions committee of at least three members of the graduate faculty. Approval for up to 12 transfer credits may be given. Application for work experience to be counted as practicum credits will be evaluated by members of the graduate faculty. Approval for up to 6 credits may be given. If credit is approved, the applicant must register for PS SC 522 for the number of credits granted. The courses in the program are scheduled with the assumption that students will enter in the fall semester. Students may apply for admission for any semester, but they may have to wait one or more semesters for particular required courses.

Applicants must submit the following: a completed application form; the application fee ($35); two copies of official transcripts from colleges or universities previously attended (including The Pennsylvania State University); a two- to three-page proposal outlining an actual social problem and a means of ameliorating that problem, identifying skills, materials, and/or facilities needed to work on the problem.

The application, fee, transcripts, proposal letter, and test scores should be sent to Penn State Harrisburg, The Capital College, Graduate Admissions, Middletown, PA 17057. In addition, applicants may be requested to visit the campus for an interview.

Degree Requirements

To qualify for the degree, 37 credits are required, 25 at the 500 level. An important part of this degree is a 6-credit fieldwork requirement, supervised by a faculty member. This required practicum experience ordinarily is taken for one semester. A master's paper for a minimum of 3 credits is required and may employ the field experience. Students who have considerable experience and clarified interests upon entering the program or students with a strong research interest may want to structure their master's paper around a specific community research problem. If the master's paper comes from the field experience, the faculty field supervisor will serve on the master's paper committee. Most part-time students are able to complete the degree in four to five semesters; the full-time student, in three to four semesters.

Student Aid

Graduate assistantships available to students in this program and other forms of student aid are described in the STUDENT AID section of the *Graduate Bulletin*.

BEHAVIORAL SCIENCES (BE SC)

401. Seminar in Behavioral Sciences (1-6)
402. Life Span Development (3)
404. Political Sociology (3)
405. Child Psychology (3)
406. Adolescence (3)
407. Small Groups Counseling (3)
408. Group Facilitation and Leadership Skills (3)
410. Human Relations (3)
412. History and Systems of Psychology (4)
421. Behavior Modification (4)

422. Experimental Psychology I (3)
423. Experimental Psychology II (3)
424. Physiological Psychology (3)
425. Cognition and Perception (3)
426. Issues in Ecological Psychology (3)
430. Sociocultural Change (3)
432. Marxism in Theory and Practice (3)
433. Culture and Personality (3)
440. Urban Sociology (3)
442. Conformity and Deviation (3)
459. Counseling Skills (3)
461. Theories and Models of Counseling (3)
462. Perspectives on Aging (3)
463. The Family (3)
464. Sex Roles and Power in America (3)
465. Psychology of Women (3)
466. Family Systems (3)
468. Industrial Psychology: Significant Issues (3)
471. Tests and Measurements (3)
480. Social Class and Inequality (3)
482. Personality Theory (3)
484. Criminology (3)
486. Mood-Altering Substances in Society (3)
488. Sociological Theory: Past and Present (3)
494. Senior Thesis in Behavioral Sciences (3-9)
496. Independent Studies (1-18)
497. Special Topics (1-9)

PSYCHOSOCIAL SCIENCE (PS SC)

500. Theories and Issues in Community Psychology (3) Contemporary issues in community psychology will be discussed within the framework of its development from clinical and social psychology.

511. Psychopathology in a Social Context (3) Psychopathology in the context of other forms of social deviancy, with attention to both social and individual concomitants of deviancy.

512. Theories and Models of Psychotherapy (3) An advanced level of psychotherapies and applications in diverse settings. Prerequisites: BE SC 402, 482, PS SC 511.

521. Roles and Methods in Community Psychology (3) Course examines and synthesizes roles, methods, and competencies relevant to community psychology, including students to utilize them in applied settings. Prerequisite: PS SC 500, SCLSC 510, 520, or permission of program.

522. Practicum (3-6) Experience in a field setting with problems confronting both clients and social welfare agencies. Prerequisites: PS SC 500, 521, SCLSC 510, 520.

530. Research (1-6) Supervised research on a master's paper. For degree candidates only.

535. Behavioral Management (3) Analysis of the social determinants of behavior and behavioral ecology. Emphasis on data collection and evaluation techniques. Prerequisite: BE SC 421.

570. Advanced Experimental Design (3) A survey of advanced statistical methods and experimental design techniques for community psychology, behavior management, and the social sciences. Prerequisites: SCLSC 470, 520.

595. Counseling Practicum (3-9) Practice in the application of counseling principles and methods under supervision; case conferences; seminar in techniques. Prerequisite: BE SC 407 or 459 or 466.

596. Individual Studies (1-9)

597. Special Topics (1-9)

SOCIAL SCIENCE (SCLSC)

470. Advanced Statistical and Design Methods (4)

510. Change Processes (3) Social change as it takes place within institutions and communities.

520. Techniques in Action Research (3) Methods for evaluating programmatic change. Prerequisite: SCLSC 320.

531. The Functioning Neighborhood (3) A study of small communities and techniques for observing them, coupled with field experience in participant observation of a specific neighborhood.

532. Community Organizing: Conflict and Change (3) The development of local issues and strategies for organizing around them.

533. Social Problems and Social Policy (3) Key social problems involving minorities, women, and workers and policy issues related to their social positions will be assessed.

541. The Organization of Human Services (3) Divisions of labor among social agencies; internal and external factors affecting the ordering of priorities.

590. Colloquium (1-3)

597. Special Topics (1-9)

PUBLIC ADMINISTRATION (PUB A)

ROBERT D. LEE, JR., *Acting Head, Public Administration*
205 Burrowes Building
814-865-2536

Degree Conferred: M.P.A.

Senior Members of the Graduate Faculty
Robert La Porte, Jr., Ph.D. (Syracuse) *Professor of Public Administration*
Robert D. Lee, Jr., Ph.D. (Syracuse) *Professor of Public Administration*
John M. Stevens, Ph.D. (SUNY-Buffalo) *Associate Professor of Public Administration*

Associate Members of the Graduate Faculty
Anthony G. Cahill, Ph.D. (Pittsburgh) *Assistant Professor of Public Administration*
Frederick J. Norling, Ph.D. (Yale) *Assistant Professor of Public Administration*
Syedur Rahman, Ph.D. (Syracuse) *Assistant Professor of Public Administration*

The Master of Public Administration degree program provides graduate professional education for individuals preparing to enter public service and for those mid-level government officials who have had substantial experience but require professional training in administration and management. The degree program has been designed to provide students with an understanding of the theories of organization, with particular reference to organizations functioning within the public sector; research methodologies for the analysis of complex systems and for seeking operational solutions to problems; and management technologies, including the use of sophisticated information systems for the maintenance of ongoing decision-making systems. Students also have an opportunity to acquire specialized knowledge in areas such as urban affairs, human services administration, budgeting and financial management, management information systems, and personnel management.

Admission Requirements
Scores from the Graduate Record Examination (GRE) are required for admission. Scores from the Graduate Management Aptitude Test (GMAT) are accepted as a substitute for GRE scores. Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin*.

Candidates with a 3.00 junior-senior grade-point average (GPA), a combined verbal and quantitative score of at least 1,000 on the GRE, and an appropriate course background will be considered for admission. Also required are two letters of recommendation, a statement of the applicant's interest and intent in the field, a complete record of work history since prior academic work, and a sample of written work. Exceptions to the minimum GPA and the GRE score may be made for applicants with

special backgrounds and abilities. Basic knowledge and skills in computing technology are required. Students who do not meet this requirement but who are admissible on other criteria will be required to take a remedial course that does not apply to the degree requirements.

Degree Requirements

Degree candidates take a required core program of 27 credits covering the theory, methodology, and management functions of public administration. An additional 12 credits of electives are used to develop areas of concentration; the courses may be taken within public administration or in other relevant departments. A master's paper is prepared in a 6-credit individual internship or team practicum. Subject to approval by the program, students with relevant professional experience in public sector administration may waive the internship-practicum and use 3 of their elective credits for their master's paper.

All requirements for the M.P.A. degree must be met within six years or a period spanning seven consecutive summers.

Student Aid

In addition to the fellowships, traineeships, graduate assistantships, and other forms of financial aid described in the STUDENT AID section of the *Graduate Bulletin,* the following awards typically have been available to graduate students in this program:

ROBERT J. MOWITZ MEMORIAL SCHOLARSHIP — Available through the Department of Public Administration to University Park and Penn State Great Valley students in the M.P.A. degree program. Amount of award varies.

PUBLIC ADMINISTRATION (PUB A)

403. PUBLIC MANAGEMENT TECHNOLOGY (3)
419. (PL SC 419) BUREAUCRACY AND PUBLIC POLICY (3)
445. ADMINISTRATIVE LAW (3)
450. INTRODUCTION TO CONTRACT MANAGEMENT (3)
451. CONTRACT ADMINISTRATION (3)
496. INDEPENDENT STUDIES (1-18)
497. SPECIAL TOPICS (1-9)

529. INTERGOVERNMENTAL RELATIONS (3) Overview of governmental agency and organizational relations across and within federal, state, substate, and local jurisdictional boundaries.

*550. CONTRACT LAW (3) Basic concepts and principles of contract law; contract clauses and provisions.

*551. PUBLIC PROCUREMENT POLICY (3) Evolution of public procurement policy through legislation, regulation, executive order; policy implementation and industry structure; assessment and projection.

*552. PURCHASING AND MATERIALS MANAGEMENT (3) Planning, analysis, and control of purchasing, production, and transportation/distribution; standards and specifications, scheduling, quality control, and inventory.

*553. MARKET RESEARCH AND ACQUISITION PLANNING (3) Forecasting issues for acquisition management personnel; demand, industrial capacity, materials, and skills; construction and use of models.

*554. COST AND PRICE ANALYSIS (3) Cost and price analysis, pricing initial awards and changes, direct and indirect costs, return on investment, profit, fee, formula pricing.

569. CONTEMPORARY CONTEXT OF AMERICAN PUBLIC ADMINISTRATION (1-3) Emergence of American public administration; external and internal organizational environment; preferences, the public good, and alternative decision-making arrangements.

571. ORGANIZATION AND MANAGEMENT THEORIES IN PUBLIC ADMINISTRATION (3-6) The role of the executive in modern government; the objectives of public administration; theories of administrative organization and practice.

*Offered only at Penn State Great Valley.

572. (PL SC 572) International Development Administration (3-6) The examination of bilateral and multilateral development assistance programs; planning, implementation, and evaluation of development programs in LDCs.

573. (PL SC 573) Comparative Public Administration (3-6) Administrative systems of selected nations on a functional basis; relationship between culture, economic and social systems, and public administration.

574. (PL SC 574) Seminar in the Administration of United States Foreign Affairs (3) Effect of cross-cultural operations on the normal process of administration of United States foreign affairs.

575. Government Personnel Management (3) Current trends in personnel systems; classification, pay, examination, performance evaluation, discipline, career development, employee rights, equal opportunity, labor-management relations.

576. Government Budgeting (3) Budget preparation, approval, execution, audit; program information and evaluation in decision making; expenditure control; revenue policies and administration; intergovernmental finance.

577. (PANAL 577) Organization and Systems Management (3) Strategic and operational view of public organizations as systems; systems analysis and decision-making methods; project and operations management; case analysis.

578. Urban Administrative Systems (3) Managing under conditions of urban growth and decay; alternative delivery systems for urban and metropolitan services in selected program areas. Prerequisite: PL SC 417.

579. Methods of Analysis and Measurement in Public Administration (3 per semester, maximum of 6) Examination and application of analytical techniques for evaluating organizational performance and program effectiveness in government agencies.

581. Public Management Information Systems (3) Examination of the role of management information in public organizations; establishment of information requirements for public programs. Prerequisites: PUB A 571, 579.

582. Legislative Management and Oversight Functions (3) Examination of the role of the legislature in overseeing the executive; emphasis on financial and program analysis techniques and problems.

583. Advanced Program/Policy Analysis (3) Advanced research methods and quantitative techniques as applied to needs assessment and program performance evaluation of public programs. Prerequisites: 6 credits of PUB A 579 or other similar course work.

585. Management Science/Operations Research Applications in Public Administration (3) Introduction to public sector applications of management science/operations research techniques, including PERT/CPM, linear programming, decision analysis, simulation, forecasting. Prerequisites: 6 credits in PUB A 579; I E 425 or M E R 442.

586. Government Financial Management and Accounting (3) Public sector financial management, capital budgeting, revenue, cash management, debt management, governmental accounting and auditing, reporting systems.

587. Human Services Administration Workshop (3) Workshop on design of management infrastructure for a comprehensive multiprogram/multiagency human services system. Prerequisites: minimum of one year's experience in a human services agency (welfare, social services, health, mental health, developmental disabilities, aging, special education) or consent of instructor; 15 graduate credits in public administration or one of the above program areas.

588. (CSPD 588) Criminal Justice Administration Seminar (3) Administration of criminal justice systems; police, courts, and corrections in the context of public safety, human services, and multijurisdictional systems.

589. Public Administration Computer Applications (1-3) Introduction to computer applications in public administration; instruction in packaged computer programs for statistical analysis/program evaluation.

591. (PL SC 591) National Security Administration (3) National security system defense organization, decision making, and administration supply management; contract administration and procurement impact of defense expenditures.

592. Information Utilization and Communication in Public Administration (1-3) Plan, organize, and write clear and timely policy issue papers, briefings, and reports; make effective oral presentations; access information sources.

593. Public Administration Policy Practicum (1-6) Policy research that evaluates and recommends alternative solutions to public problems; written and oral briefings for policymakers. Prerequisites: 15 graduate credits in public administration.

594. Research Seminar in Public Administration (1-6) Application of research methods to problems of organization, management, and policy in public agencies; preparation of research project and report.

595. Internship in Public Administration (1-6)

596. Individual Studies (1-9)

597. Special Topics (1-9)

PUBLIC ADMINISTRATION (P ADM)

JAMES E. SKOK, *Head, Division of Public Affairs*
Penn State Harrisburg, The Capital College
Middletown, PA 17057
717-948-6050

Degree Conferred: M.P.A.

Senior Members of the Graduate Faculty
Robert J. Bresler, Ph.D. (Princeton) *Professor of Public Policy*
Rupert F. Chisholm, Ph.D. (Case Western Reserve) *Associate Professor of Management*
Irving Hand, M.C.P. (MIT) *Professor of State and Regional Planning*
Christopher K. McKenna, Ph.D. (NYU) *Associate Professor of Management Science*
Robert F. Munzenrider, Ph.D. (Georgia) *Associate Professor of Public Administration*
James E. Skok, Ph.D. (Maryland) *Associate Professor of Public Administration*
James T. Ziegenfuss, Jr., Ph.D. (Pennsylvania) *Associate Professor of Social Systems Sciences*

Associate Members of the Graduate Faculty
J. Marvin Bentley, Ph.D. (Tulane) *Associate Professor of Economics*
Carol Nechemias, Ph.D. (Ohio State) *Assistant Professor of Public Policy*
John Ramirez, Ph.D. (Michigan) *Associate Professor of Criminal Justice*
Robert A. Simko, Ph.D. (Indiana) *Associate Professor of Social Science and Geography*
Michael L. Young, Ph.D. (Pittsburgh) *Assistant Professor of Politics and Public Affairs*

The Penn State Harrisburg M.P.A. program is approved by the National Association of Schools of Public Affairs and Administration. It is intended to prepare individuals for professional careers as administrators, project directors, or staff analysts in local, state, or federal government; health care organizations; human service and public safety agencies; and other service organizations.

The location of the Penn State Harrisburg campus at the state capital of Pennsylvania provides excellent opportunities for field study experiences in state government agencies, cities and smaller municipalities, county and federal agencies, large hospitals, Penn State's Milton S. Hershey Medical Center, and other professional and public-service organizations. The 9-credit field study, which extends over two semesters, may be waived for students who have at least three years of full-time related professional experience.

Current areas of faculty research interests include quality of worklife, organizational change, computers in public administration, the legislative process, the budget process, health policy and planning, oversight and evaluation, state government decision making, political campaigns, and public opinion polling.

Admission Requirements
Students with a 3.00 junior-senior average and a minimum of 3.00 in any prior graduate course work will be considered for admission. Exceptions may be made for applicants with special backgrounds,

abilities, and interests, or with professional experience. Applicants lacking a 3.00 average may be considered for admission by attaining a score on the Graduate Record Examination (GRE) of 1,000 or above and by achieving grades of B or above as provisional students in all prerequisite courses and P ADM 500 and 501. Through course work or experience, applicants are expected to have had some preparation in American government, algebra, introductory statistics, economics, accounting, computer methods, and behavioral sciences. Students without such preparation may take nongraduate credit courses offered by the program or may complete assigned readings. Applicants will submit a short essay outlining their career plans. Requirements listed above are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin*.

Degree Requirements

The M.P.A. degree requires a minimum of 45 credits, including 9 credits of a faculty-supervised field study in a public agency in the student's field of interest. This requirement may be waived for students who have at least three years of full-time professional experience in relevant administrative or staff work prior to graduation.

Students complete a master's paper, either as part of their field study experience or as one of their electives. The master's project is a professional paper or other undertaking rather than an academic thesis.

There is no foreign language requirement.

Consistent with the view that an M.P.A. degree is broad-based, the program requires the following courses: P ADM 500 — Public Organization and Management; P ADM 501 — Administration and the Political Process; P ADM 502 — Government Fiscal Decision Making; P ADM 503 — Research Methods; P ADM 504 — Legal and Social Context of Public Administration; P ADM 510 — Organization Behavior. The student completes six other courses and may specialize in one of the following concentrations: government administration, health care management, human resources, or computers and analysis.

There is no qualifying or comprehensive examination.

Student Aid

Graduate assistantships available to students in this program and other forms of student aid are described in the STUDENT AID section of the *Graduate Bulletin*. Research aide positions, offering a stipend approximately equal to the tuition for full-time study, and paying internships with various governmental and other service organizations also are available.

PUBLIC ADMINISTRATION (P ADM)

390G. Accelerated American Government (2)
391G. Quantitative Methods Review For Public Administration (2)
393G. Introductory Governmental and Not-for-Profit Accounting (2)
394G. Accelerated Economic Analysis (2)
400. Health Systems Organization (3)
486. Applied Statistical Packages (1)
490. Computer Applications in Public Administration (3)

500. Public Organization and Management (3) Development of public administration; administrative theory and practice in public organizations.

501. Administration and the Political Process (3) Analysis of the relationship of administration to the political processes that shape public policy formulation and execution. Prerequisites: 3 credits in American government, 3 credits in micro/macro economics.

502. Governmental Fiscal Decision Making (3) Nature, function, and technique of governmental budgeting viewed as mechanism for allocating resources among alternative public uses. Prerequisites: P ADM 500, 501.

503. .(UR PL 500) Research Methods (1-3) Examination of research methodologies relevant to administration, planning, and public policy. Prerequisite: 3 credits in statistics.

504. Legal and Social Context of Public Administration (3) The legal framework for public administration, the administration of public law, conduct of legal research, and socio-legal issues. Prerequisite: 3 credits in American government.

505. Personnel Management: Public and Nonprofit Sector (3) Concepts and approaches contributing to effective use of human resources in public and nonprofit organizations; legal issues and requirements. Prerequisites: P ADM 500, 510.

510. (MNGMT 510) Organizational Behavior (3) Examination of concepts of human behavior in formal organizations, systems analysis, conceptual models, and decision processes.

511. (MNGMT 511) Organizational Change and Development (3) Theory of organizational change and development; case analysis of applications in actual situations. Prerequisites: P ADM (MNGMT) 510; P ADM 500 or MNGMT 500.

512. Issues in Human Resources (3) A survey of major human resource issues such as job stress, burnout, and the many forms of discrimination in organizations. Prerequisites: P ADM 505, 510.

515. (MNGMT 515) Labor Management Relations (3) Labor relations issues; collective bargaining agreement, negotiations, and administration; legal framework of collective bargaining; labor relations in larger social context.

520. Management Science Applications (3) Applications of quantitative models for the administrator's viewpoint. Explanation of the underlying models, assumptions made, questions explored, without mathematical detail. Prerequisites: P ADM 502, 503.

522. Government Financial Management (3) Theories and techniques of financial planning and control, with emphasis on their application in government and nonprofit agencies. Prerequisites: P ADM 502, 3 credits in accounting.

524. Administrative Law (3) Statutory and judicial controls upon administrative discretion. Administration of rule making, rate setting, licensing, adjudication. Judicial review and citizen advocacy. Prerequisites: P ADM 500, 501, 504.

530. Field Study in Public Administration (1-5 per semester, maximum of 9) Analysis and written reports on current problems/projects for a public agency in student's concentration area. Readings in concentration area. Prerequisite: permission of program chairman.

532. Urban Government (3) Administrative processes and policy problems associated with managing urban communities; political, intergovernmental, fiscal, structural, and analytical concepts in urban government.

540. Administrative Policy Formulation (3) Analysis of administrative problems from a total organization viewpoint. Case studies of actual organizations are used for analysis.

541. Health Economics and Policy (3) Public policy issues, health system components from economic perspective. Economic analysis of health sector, medical markets, health care regulation. Prerequisites: P ADM 440, introductory economics.

545. Health Financial Management (3) Theory and techniques of financial management applied to health organizations; forecasting, control systems, working capital, capital budgeting, and institutional financing. Prerequisites: P ADM 440, 541, and elementary accounting.

546. Health Planning for Public Administration (3) Comprehensive planning and program planning for health services, facilities, and manpower; social, economic, and political considerations; methodological problems. Prerequisites: P ADM 503, 541.

550. Program Planning and Evaluation (3) Analysis and evaluation of public programs and systems from the perspectives of policy development and administrative planning and management. Prerequisite: P ADM 503 or permission of instructor.

554. Master's Project (1-3) Student independently executes an applied professional or research project involving the analysis of a management or a public policy problem. Prerequisite: P ADM 503.

556. State Government Administration (3) Study of structures, systems, processes, problems, and issues affecting state government administration; case studies, field observations, and research. Prerequisites: P ADM 500, 501.

557. Federalism and Intergovernmental Relations (3) Study of the impact of a federal system of government on the administration of public functions. National-state-local dimensions. Prerequisites: P ADM 500, 501.

558. Legislative Processes (3) Legislatures in American government, emphasizing comparative state legislatures: constitutional patterns; organization, administration; interaction with bureaucracy, constituencies, and organized interests. Prerequisites: P ADM 500, 501.

560. Strategic Planning (3) A survey of strategic planning purposes, approaches, and methods, and expected outcomes in small and large organizations. Prerequisite: P ADM 500.

570. Scope and Methods of Public Administration (3) Examination of theoretical approaches to Public Administration and the role of theory in the field. Prerequisites: P ADM 500, 501, 502, 503, 504, 510.

571. Seminar in Organization Theory (3) Selected theories of organizations and their applications to the study of public organizations. Prerequisite: P ADM 570.

572. Research and Theory in Political Institutions (3) Selected research paradigms and their application in the study of political institutions. Prerequisite: P ADM 570.

573. Research and Theory in Policy Analysis (3) The five major modes of policy inquiry, the analytic methodologies associated with each, and their applications to real world problems. Prerequisite: P ADM 570.

574. Research and Theory in Public Management (1) Theoretical and empirical bases for selected functions of public managers. Prerequisite: P ADM 570.

575. Advanced Research Design (3) Experimental, quasi-experimental, survey, aggregate, and other research designs applied to organizational, managerial, and policy analysis research problems. Prerequisite: P ADM 570.

576. Multivariate Statistical Methods (3) Multivariate statistical methods, with special emphasis on their use in organizational, managerial, and policy analysis research settings. Prerequisite: P ADM 575.

590. Colloquium (1-3)

591. Readings in Public Administration (3) Directed readings in selected areas of public administration. Prerequisite: P ADM 576.

596. Individual Studies (1-9)

597. Special Topics (1-9)

RECREATION AND PARKS (RC PK)

HERBERTA M. LUNDEGREN, *Graduate Program Administrator*
203 Henderson Building South
814-865-1851

Degrees Conferred: Ph.D., M.S., M.Ed., M.Rc.Pk.

Senior Members of the Graduate Faculty
Diana R. Dunn, Ph.D. (Penn State) *Professor of Recreation and Parks*
Patricia Farrell, D.Ed. (Penn State) *Associate Professor of Recreation and Parks*
Geoffrey C. Godbey, Ph.D. (Penn State) *Professor of Recreation and Parks*
Herberta M. Lundegren, Ph.D. (Iowa) *Professor of Physical Education and Recreation*
Elwood L. Shafer, Ph.D. (SUNY-Syracuse) *Professor of Recreation and Parks*

Associate Members of the Graduate Faculty
Monty L. Christiansen, M.L.A. (Iowa State) *Associate Professor of Recreation and Parks*
John P. Dattilo, Ph.D. (Illinois) *Assistant Professor of Recreation and Parks*
Richard J. Gitelson, Ph.D. (Texas A&M) *Associate Professor of Recreation and Parks*
Alan R. Graefe, Ph.D. (Texas A&M) *Associate Professor of Recreation and Parks*
Frank B. Guadagnolo, Ph.D. (Oregon State) *Assistant Professor of Recreation and Parks*

The graduate program is designed to prepare students for administrative, supervisory, research, and teaching positions in public and private recreation and park systems, in colleges and universities, in voluntary agencies and institutions, and in commercial ventures.

The program is oriented to meet the specific needs and research interests of the candidate. Students may pursue interests in the community, including public park and recreation systems, voluntary agencies, and private commercial enterprises; tourism; institution and community-oriented therapeutic settings concerned with many different disabilities and utilizing a variety of activity modalites; park planning, interpretive services, outdoor education, and outdoor recreation services.

Admission Requirements

Scores from the Graduate Record Examination (GRE), or from a comparable substitute examination accepted by the graduate program, are required for admission to the doctoral program and recommended for applicants to the master's program. Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin*.

For admission to the graduate program, a bachelor's or master's degree is required. Candidates from majors other than recreation and parks are welcome to apply; however, additional course work is required. Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. All students must write a thesis.

There are no additional requirements beyond the general Graduate School requirements for the master's degree. Doctoral degree requirements include a 3.20 average for the master's degree work; understanding of a foreign culture; computer competency; and at least one year's experience in the recreation and parks field before completion of the degree.

Student Aid

In addition to the fellowships, traineeships, graduate assistantships, and other forms of financial aid described in the STUDENT AID section of the *Graduate Bulletin*, the following award typically has been available to graduate students in this program:

U.S. Office of Education Traineeships in Therapeutic Recreation — Open to graduate students specializing in therapeutic recreation; stipend $5,000 (two semesters). Apply through the Graduate Program in Recreation and Parks.

RECREATION AND PARKS (RC PK)

410. Marketing of Recreation Services (3)
425. Interpretive Services (3)
430. Environmental Education Methods and Materials (3)
433. Evaluation in Recreation and Parks (3)
434. Functional Planning and Evaluation of Park Support Systems (3)
435. Recreation Facility Planning and Maintenance Management (3)
450. Recreation Issues (1)
460. Legal Aspects of Recreation and Parks (3)
462. (SOC 462) The Sociology of Leisure (3)
465. Administration of Recreation and Parks (3)
470. Park Management (3)
477. Problems in Therapeutic Recreation/Special Recreation (3)
495. Practicum (10-15)
496. Independent Studies (1-18)
497. Special Topics (1-9)

500. (EXSCI 500) Individual Study and Research Projects (1-10) Prerequisite: RC PK 530.

515. Program Development and Supervision (3) Critical analysis of the individual, political, and societal determinants of recreation programming; demonstration projects; evaluative procedures, research functions in programming. Prerequisite: RC PK 256.

522. Seminar in Curriculum, Administration, and Evaluation of Environmental Education Programs (3)

525. Behavioral Patterns of the Outdoor Recreationist (3) Patterns of time and space use; user characteristics; meaning of participation; facilitation of environment-use enhancement. Prerequisite: RC PK 320.

527. Social Psychology of Leisure (3) Application of the methods, constructs, and theory of social psychology to the study of leisure, outdoor recreation, and therapeutic recreation. Prerequisites: PSY 417, SOC 403.

530. (HL ED 530, EXSCI 530) Research Techniques in Health and Physical Education and Recreation (3) Research techniques, including methods, research design, techniques for data collection, as applied to relevant problems in the health education field.

533. Recreation Studies, Surveys, and Appraisals (3) Advanced research procedures related to special recreation and park problems. Prerequisites: RC PK 530 and 3 credits in statistics.

540. Public and Private Recreation Lands and Waters (3) Public and private roles and interactions, allocation of resources, use policies, open space concepts, private enterprise developments, legal controls.

545. Philosophical and Social Bases of Recreation (3) Philosophical and social bases of recreation; analysis of critical issues of recreation for philosophical and social implications.

550. Seminar in Recreation and Parks (1-6)

560. Administrative Problems of Recreation and Parks (3) Special problems of recreation and park departments; legal powers and liability; departmental organization, financing, personnel policies, and staff development. Prerequisite: RC PK 465.

570. Conceptual Bases for Therapeutic Recreation (3) Issues in the application of concepts in therapeutic recreation from a multidisciplinary perspective; evaluation and research. Prerequisite: RC PK 477.

590. Colloquium (1-3)

596. Individual Studies (1-9)

597. Special Topics (1-9)

RECREATION AND PARKS (RC PK)

M. TIPTON RAY, *Coordinator*
Penn State Harrisburg, The Capital College
Middletown, PA 17057
717-948-3535

Degree Conferred: M.Rc.Pk.

Senior Members of the Graduate Faculty
Diana R. Dunn, Ph.D. (Penn State) *Professor of Recreation and Parks*
Patricia Farrell, D.Ed. (Penn State) *Associate Professor of Recreation and Parks*
Geoffrey C. Godbey, Ph.D. (Penn State) *Professor of Recreation and Parks*
Herberta M. Lundegren, Ph.D. (Iowa) *Professor of Physical Education and Recreation and Parks*
Elwood L. Shafer, Jr., Ph.D. (SUNY–Syracuse) *Professor of Recreation and Parks*

Associate Members of the Graduate Faculty
Monty L. Christiansen, M.L.A. (Iowa State) *Associate Professor of Recreation and Parks*
John P. Dattilo, Ph.D. *Assistant Professor of Recreation and Parks*
Richard J. Gitelson, Ph.D. (Texas A&M) *Associate Professor of Recreation and Parks*
Alan R. Graefe, Ph.D. (Texas A&M) *Associate Professor of Recreation and Parks*
Frank B. Guadagnolo, Ph.D. (Oregon State) *Associate Professor of Recreation and Parks*
Ralph W. Smith, Ph.D. (Penn State) *Assistant Professor of Recreation and Parks*

Admission Requirements
For admission, students must have received a baccalaureate degree from an accredited college or university and have a junior-senior grade-point average of 3.00. In addition, students should have recreation-and-parks-related career goals and one year of experience in an appropriate recreation and parks setting. Requirements listed above are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin*.

Degree Requirements
The program involves three general areas of study: required course work, selections that build on an area of specialization, and electives. The program requires 15 credits at the 500-course level and a culminating work-related scholarly paper that demonstrates the ability to conceptualize and state clearly the purpose of an investigation, study, analysis, or evaluation; to obtain and analyze information; to draw conclusions logically; and to make recommendations for professional practice. Students may not register as degree candidates until they are admitted to the program.

Other Relevant Information
The Master of Recreation and Parks program is oriented toward individuals already engaged in the leisure service profession who will be employed while pursuing their degrees. Appropriate program goals and an individualized course of study are developed with each student. Transcripts are evaluated by the program coordinator at Penn State Harrisburg. Previous graduate work, including Penn State credit workshops taken at the University Center at Harrisburg, is evaluated to determine applicability of transfer credit.

Student Aid
Graduate assistantships available to students in this program and other forms of student aid are described in the STUDENT AID section of the *Graduate Bulletin*.

RURAL SOCIOLOGY (R SOC)

DONALD M. CRIDER, *Interim Head of the Department of Agricultural Economics and Rural Sociology*
6 Weaver Building
814-865-5461

Degrees Conferred: Ph.D., M.S., M.Agr.

Senior Members of the Graduate Faculty
Robert C. Bealer, Ph.D. (Michigan State) *Professor of Rural Sociology*
Charles O. Crawford, Ph.D. (Cornell) *Professor of Rural Sociology*
Wayne A. Schutjer, Ph.D. (Michigan State) *Professor of Agricultural Economics*
C. Shannon Stokes, Ph.D. (Kentucky) *Professor of Rural Sociology*
Rex H. Warland, Ph.D. (Iowa State) *Professor of Rural Sociology*
Kenneth P. Wilkinson, Ph.D. (Mississippi State) *Professor of Rural Sociology*
Fern K. Willits, Ph.D. (Penn State) *Professor of Rural Sociology*

Associate Members of the Graduate Faculty
Donald M. Crider, Ph.D. (Penn State) *Professor of Rural Sociology*
Daryl K. Heasley, Ph.D. (Penn State) *Associate Professor of Rural Sociology Extension*
Dan E. Moore, Ph.D. (Wisconsin) *Associate Professor of Rural Sociology*
Carolyn E. Sachs, Ph.D. (Kentucky) *Assistant Professor of Rural Sociology*
Joan Thomson, Ph.D. (Wisconsin) *Assistant Professor of Rural Sociology Extension*
James Van Horn, Ph.D. (Ohio State) *Associate Professor of Rural Sociology Extension*

All degree programs emphasize a comprehensive understanding of the various facets of societal organization pertinent to the rural sector. While scope is encouraged, areas of special interest and research include food choice, instigated social change, community structure, leadership, population, rural health, rural community services, the structure of agriculture, and the ecology of rurality in industrialized and urbanized society.

Admission Requirements
Scores from the Graduate Record Examination (GRE), or from a comparable substitute examination accepted by a graduate program and authorized by the dean of the Graduate School, are required for admission. At the discretion of a graduate program, a student may be admitted provisionally for graduate study in a program without these scores. Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin*.

Prerequisites for the master's program include 3 credits in rural sociology, 3 credits in sociology, and 3 additional credits in either field. If the entering student does not have these prerequisites, they must be made up at the University during the early part of the master's program.

Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

Degree Requirements
All students are required to have training in sociological theory, statistics, and research methods.

There is no foreign language requirement for the Ph.D. degree; the student is expected to substitute

such courses and instruction necessary to generate superior capabilities of inquiry into an analysis of basic and/or applied rural sociological problems.

Student Aid

Graduate assistantships available to students in this program and other forms of student aid are described in the STUDENT AID section of the *Graduate Bulletin*.

RURAL SOCIOLOGY (R SOC)

402. Consumer Behavior and Agricultural Business (3) *Herrmann*
422. Family in Rural Society (3) *Van Horn*
425. Poverty Analysis: People and Programs (3) *Van Horn*
444. Social Change in Rural America (3) *Sachs*
452. Rural Organization (3) *Wilkinson*
496. Independent Studies (1-18)
497. Special Topics (1-9)
499. Foreign Study — Rural Society (1-12)

501. Development of Rural Sociology (3) Historical development with emphasis on American rural sociology. Even years. *Crider*

502. Use of Theory in Rural Sociology (3) Examine and evaluate metasociology of alternative theoretical systems applicable to rural society, with emphasis on American society. Prerequisites: 24 credits in sociology, including 6 in rural sociology and 3 in sociological theory. Even years. *Bealer*

505. Leadership Development (3) Exploration, understanding, and application of leadership roles, strategies, and principles in group and community settings. Prerequisites: R SOC 305W; 6 credits in social or behavioral sciences. *Heasley*

510. Rural Migration (2) Rural migration research and theory; application to governmental and community problems. Odd years. *Stokes*

514. Values in Rural Society (3) Relevance for policy issues of persisting cultural and value differences between rural and urban sectors of American society. Prerequisites: R SOC 011, 444; 6 additional credits in rural sociology. Odd years. *Bealer*

515. (EXTED 515) The Cooperative Extension Organization (3) The Cooperative Extension Service as a social system, with emphasis on techniques of organization and program development. Prerequisites: 9 credits in education, communication, and/or social sciences. *Thomson*

516. Change in Rural Society (3) Social change in rural society, emphasizing prediction and control of the change process. Even years. *Wilkinson.*

517. International Rural Social Change (3) Implications of planned change for international rural societies, considering basic structural constraints, known institutional linkages, and potential synergetic consequences. Odd years. *Crider.*

522. Data Analysis in Rural Sociology (1) Analysis of research data in rural sociology using computer library programs. Prerequisite or concurrent: AG 400. *Willits*

525. Fertility, Population Change, and Development (3) Fertility and population growth in less-developed countries; theories of fertility change, agricultural development, and population policies. Prerequisite: SOC 423 or prior work in population. Odd years. *Stokes*

551. Rural Sociology Seminar (1-6) Prerequisites: 6 credits in rural sociology, sociology, or psychology.

573. Methods of Survey Data Analysis (3) Use of multivariate procedures in the analysis of survey data in the rural social sciences. Prerequisite: AG 400. *Willits*

596. Individual Studies (1-9)

597. Special Topics (1-9)

602. Supervised Experience in College Teaching (1-3 per semester, maximum of 6)

SCHOOL PSYCHOLOGY (S PSY)

JOSEPH L. FRENCH, *Professor-in-charge of the Graduate Program in School Psychology*
104 Cedar Building
814-865-1881

Degrees Conferred: Ph.D., M.S., M.Ed.

Senior Members of the Graduate Faculty
Francis J. Di Vesta, Ph.D. (Cornell) *Professor of Education and Psychology*
Joseph L. French, Ed.D. (Nebraska) *Professor of Special Education and Educational Psychology*
Leon Gorlow, Ph.D. (Columbia) *Professor of Psychology*
Louise F. Guerney, Ph.D. (Penn State) *Associate Professor of Human Development*
Robert L. Hale, Ph.D. (Nebraska) *Associate Professor of Education*
Donald B. Keat II, Ph.D. (Temple) *Professor of Education*
Joseph O. Prewitt-Diáz, Ph.D. (Connecticut) *Associate Professor of Education*
John A. Salvia, D.Ed. (Penn State) *Professor of Special Education*

This intercollege program is based primarily on courses in educational psychology, psychology, and special education. In addition, courses are often drawn from counselor education, individual and family studies, educational theory and policy, educational administration, and curriculum and instruction. The objective is to develop a psychologist capable of providing health care who is interested in and knowledgeable about education and psychology in the school setting. The school psychologist must utilize professional skill and knowledge about children and youth to make contributions that are meaningful to, and utilized by, teachers, other school personnel, and parents. The development of competencies needed by a fully qualified school psychologist requires at least the education represented by a doctoral degree.

Practicum facilities, in addition to those in nearby public schools, include the Center for Educational Diagnosis and Remediation, the School Psychology Clinic, the Communication Disorders Clinic, the Reading Center, and the Psychology Clinic. Facilities for work with children are also available through other academic units, as well as through assistantship assignments.

Admission Requirements

Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin*.

Only those students who anticipate a doctoral degree will be admitted. Students are selected within the limitations of program facilities. Priority is given to applicants with work experience with children.

An undergraduate major emphasizing work in psychology and/or education is preferred, but students with fewer than 20 upper-division credits in psychology, educational psychology, or special education may be admitted with limited deficiencies to be fulfilled concurrently with their graduate work. Requirements for admission include a minimum of one-third of graduate credits of A quality; satisfactory recommendations from two or more professors, preferably psychologists; and a score of 1000 or higher on the two general sections or a score of 1500 or higher, including the analytical or an advanced test, of the Graduate Record Examination, or a score of 58 or higher on the Miller Analogies Test. Exceptions may be made for students with special backgrounds, abilities, and interests.

Master's Degree Requirements

Students entering the program with a bachelor's degree complete the M.S. as prescribed by the Graduate School. Students qualifying for a certificate to practice in the schools must have a master's degree, about 60 graduate credits, and a practicum as described in our packet for prospective students.

Doctoral Degree Requirements

Students may be admitted with a master's degree from school psychology programs from other institutions or from related programs in this or other universities. The doctoral program includes a predissertation research requirement, which may be satisfied with a master's thesis; the core program described below (which qualifies the candidate for a school psychology certificate); a special proficiency of 9 to 15 credits; an internship; and a dissertation.

Students completing the School Psychology Core Program will have courses in the biological bases of behavior, the cognitive bases of behavior, the social bases of behavior, personality theory or abnormal psychology, human development, professional ethics and standards, research design and

methodology, statistics, psychometrics, counseling theory, educational foundations, educational administration, the education of exceptional children, and curriculum.

Other Relevant Information

The professor-in-charge of the major serves as each student's academic and professional adviser at least through the first year of study. Each member of the faculty listed above may serve as an adviser for research.

The program has been accredited by the American Psychological Association, the National Commission for Accreditation in Teacher Education, and the Pennsylvania Department of Education.

Student Aid

Graduate assistantships available to students in this program and other forms of student aid are described in the STUDENT AID section of the *Graduate Bulletin*.

SCHOOL PSYCHOLOGY (S PSY)

496. Independent Studies (1-18)
497. Special Topics (1-9)

500. Professional Issues in School Psychology (1-3) Orientation to the field through study of unique problems, current issues, ethical and legal matters, unique cases, and research projects.

510. Supervision of Pupil Service Personnel (1-10) Program supervision and professional leadership in university clinics and school systems. Prerequisite: S PSY 595A.

554. Psychological and Educational Evaluation of Exceptional Children (3) Administration and interpretation of individual tests other than the Stanford-Binet, WISC, WAIS. Prerequisite: S PSY (PSY) 559.

556. Psychological Assessment of Preschool and School-Aged Children (2) Study of cognitive/affective tests; use of systems — analytic, multivariate statistical, actuarial methods of data combination in decision-making processes. Prerequisites: EDPSY 400, 450; EDPSY 554 or S PSY (PSY) 559.

559. (PSY 559) The Individual Psychological Examination (3) Demonstrations and practice in widely used ability and aptitude tests; psychological report writing. Prerequisites: 15 credits in psychology and a course in measurement.

595A. Practicum in School Psychology (1-6) Clinical experience with children under supervision in a variety of settings requiring service, including practice in synthesizing data and observations.

595B. Internship in School Psychology (1-10) Long-term placement in settings providing work for school psychologists with children, parents, teachers, administrators, and service agencies, under supervision.

596. Individual Studies (1-9)

SOCIOLOGY (SOC)

FRANK CLEMENTE, *Head of the Department*
201B Oswald Tower
814-865-0172

Degrees Conferred: Ph.D., M.A.

Senior Members of the Graduate Faculty

Roy L. Austin, Ph.D. (Washington) *Associate Professor of Sociology*
Richard J. Bord, Ph.D. (Iowa) *Associate Professor of Sociology*
Frank Clemente, Ph.D. (Tennessee) *Professor of Sociology*
Clifford C. Clogg, Ph.D. (Chicago) *Professor of Sociology and Statistics*
Gordon F. De Jong, Ph.D. (Kentucky) *Professor of Sociology*
Joseph E. Faulkner, Ph.D. (Penn State) *Associate Professor of Sociology*
Mary L. Fennell, Ph.D. (Stanford) *Associate Professor of Sociology*
Dennis P. Hogan, Ph.D. (Wisconsin-Madison) *Professor of Sociology*

Craig R. Humphrey, Ph.D. (Brown) *Associate Professor of Sociology*
John H. Kramer, Ph.D. (Iowa) *Associate Professor of Criminal Justice and Sociology*
Roland J. Pellegrin, Ph.D. (North Carolina) *Professor of Sociology*
Darrell J. Steffensmeier, Ph.D. (Iowa) *Associate Professor of Sociology*
Yoshimitsu Takei, Ph.D. (California) *Associate Professor of Education and Sociology*
George A. Theodorson, Ph.D. (Cornell) *Professor of Sociology*
Edward J. Walsh, Ph.D. (Michigan) *Associate Professor of Sociology*
David L. Westby, Ph.D. (Michigan State) *Associate Professor of Sociology*

Associate Members of the Graduate Faculty
Vicki Abt, Ph.D. (Temple) *Associate Professor of Sociology*
E. Allan Brawley, D.S.W. (Pennsylvania) *Professor of Social Work*
Nancy E. Durbin, Ph.D. (Washington) *Assistant Professor of Sociology*
Sheldon R. Gelman, Ph.D. (Brandeis) *Professor of Social Work*
Michael P. Johnson, Ph.D. (Michigan) *Associate Professor of Sociology*
Daniel T. Lichter, Ph.D. (Wisconsin) *Associate Professor of Sociology*
Joan D. Mandle, Ph.D. (Bryn Mawr) *Associate Professor of Sociology*
Emilia E. Martinez-Brawley, D.Ed. (Temple) *Professor of Social Work*
Michael P. Massagli, Ph.D. (Wisconsin) *Assistant Professor of Sociology*
Jan E. Mutchler, Ph.D. (Texas) *Assistant Professor of Sociology*
Lauri Perman, Ph.D. (Harvard) *Assistant Professor of Sociology*
Marylee C. Taylor, Ph.D. (Harvard) *Associate Professor of Sociology and Education*

The graduate program in Sociology offers advanced education for students who intend to pursue academic careers in sociology or who aspire to nonacademic research positions.

The M.A. and Ph.D. programs provide training in general social theory, research methodology, statistics, and a number of traditional and developing substantive specialities. In consultation with faculty advisers, students select areas of concentration from among possibilities that include demography, deviance/criminology, environmental/ecology, large-scale social organization, social psychology, family, gender, race relations, work and organizations, social movements, methodology and statistics. Some course work outside the department is expected. Students may elect to pursue a joint degree in Demography and Sociology; for details, refer to the Demography program description.

All first-year students who intend to pursue doctoral work are expected to earn an M.A. degree in their normal progress to the Ph.D.

Other areas of study related to sociology, such as rural sociology, social psychology, geography, economics, business administration, statistics, cultural anthropology, political science, health and human behavior, are offered in other departments of the University.

Special department-related research and training facilities include on-site computer terminals, a small groups research laboratory, and the Population Issues Research Center. Additional University facilities used by sociology faculty and graduate students include the Computation Center (containing information about the extensive data bases provided through the Inter-University Consortium for Political and Social Research), the Institute for Policy Research and Evaluation, and the Gerontology Center.

Admission Requirements
Candidate selection is based on undergraduate grades (and where applicable, record of previous graduate work); Graduate Record Examination (GRE) scores (verbal, quantitative, and analytic); letters of recommendation; statement of purpose; and a sample of written work, such as a term paper. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Students with limited prior training in sociology may be accepted, with the provision that they make up background deficiencies in the early part of their graduate program.

Degree Requirements
The department offers two options leading to the M.A. For the M.A. preparatory to the Ph.D., students must write a thesis. For the nonthesis M.A., students must submit a professional paper approved by a committee of three faculty members. Required courses for either M.A. option include one seminar each in research methods, social theory, and social statistics.

For the Ph.D., one additional specified seminar in social theory and one in social statistics are required, along with substantive courses in the student's areas of concentration. A candidacy examination is required of all students seeking the Ph.D. This evaluation by the department graduate faculty is based on the student's seminar papers, research proposal, and record of course performance.

The Department of Sociology has no formal foreign language or communication requirement.

However, students are encouraged to pursue additional training in statistics, computer science, foreign language, technical writing, specialized methods, or specialized theory that will further dissertation and career plans.

Student Aid

In addition to the fellowships, traineeships, graduate assistantships, and other forms of financial aid described in the STUDENT AID section of the *Graduate Bulletin,* many students admitted to the program are supported through teaching assistantships. Research assistantships also are available to qualified students through individual faculty members' grants and contracts. A number of federal agencies also offer fellowships for graduate study in sociology.

SOCIOLOGY (SOC)

400. Advanced General Sociology (3)
401. Social Institutions (3)
403. Advanced Social Psychology (3)
404. Social Influence and Small Groups (3)
405. Sociological Theory (3)
406. Sociology of Deviance (3)
408. Urban Ecology (3)
409. (SOC W 409) Racial and Ethnic Inequality in America (3)
412. Crime, Social Control, and the Legal System (3)
414. Criminal Careers and the Organization of Crime (3)
416. (EDTHP 416) Sociology of Education (3)
417. Law and Society (3)
420. (EM SC 420, S T S 420) Energy and Modern Society (3)
423. Social Demography (3)
424. Social Change (3)
429. Social Stratification (3)
430. Family in Cross-Cultural Perspective (3)
432. Social Movements (3)
435. Social Gerontology (3)
436. Polling and Public Opinion (4)
444. Complex Organizations (3)
446. Political Sociology (3)
447. (COM S 447) Environment, Energy, and Society (3)
450. Community Organization (3)
453. (ANTH 453) Religion of Traditional Peoples (3)
454. The City in Postindustrial Society (3)
455. Work and Occupations (3)
461. Sociology of Religion (3)
462. (RC PK 462) The Sociology of Leisure (3)
470. Intermediate Social Statistics (4)
471. Qualitative Research Methods in Sociology (3)
473. Methods for Demographic Analysis (3)
496. Independent Studies (1-18)
497. Special Topics (1-9)
499. Foreign Study — Sociology (2-6)

500. Introduction to Graduate Study in Sociology (1) Required of all incoming graduate students in sociology.

501. Proseminar in Large-Scale Social Organization (3) Perspectives on large-scale social organization, emphasizing the division of labor in stratification, formal organizations, politics, work, economy, and education.

502. Theories of Society I (3) Review and analysis of trends and controversies in sociological theory from late eighteenth-century beginnings through the nineteenth century.

503. Theories of Society II (3) Review and analysis of trends and controversies in sociological theory in the twentieth century.

504. Issues in Sociological Theory (3) Seminar in the sociology of sociology, sociology of knowledge, and the philosophy of science, focusing on current theory and methodology.

505. Contemporary Sociological Theory (3) Comparative evaluation of major theoretical perspectives in sociology today; critical analysis of current trends; examination of crucial contemporary problems.

511. Research Methods in Criminology and Deviance (3) Review of methodological issues; design and conduct of research; analysis and interpretation of findings; ethical and policy issues.

512. Seminar in Deviant Behavior (3) Survey of theoretical and substantive issues in deviance and criminology, with emphasis on critical review of theories.

513. Sociological Research Methods (3) Critical review of methodological issues; research designs; analysis and interpretation of findings.

514. Instrumentation and Data Collection in Social Research (3) Chief techniques for collecting data in social research: interviews and questionnaires, laboratory and field observation, unobtrusive measures. Prerequisite: SOC 513 or equivalent course in research methods.

521. Family Demography (3) Current family demographic research on nuptiality, divorce, household composition, female employment, migration, and fertility.

523. Population Theory and Policy (3) Multidisciplinary population theory and research in developed and developing nations; relationships with contemporary population policy issues. Prerequisite: SOC 423 or prior work in population or human ecology.

535. Sociology of Aging (3) Current research and methodological issues in the sociological study of aging.

544. Current Issues in Complex Organizations (3) Critical survey of recent developments in sociological study of organizations and the theory of bureaucracy, including reciprocal effects on environments. Prerequisite: SOC 444.

545. Economy and Society (3) Major social theorists' views on relationships of economy and society; competing sociological and economic models in contemporary social research.

546. Seminar in Political Sociology (3) Analysis of issues and problems in political sociology. Topical emphasis varies. Prerequisite: SOC 446.

547. Environmental Sociology (3) The development of environmental sociology; research issues in the study of social organization, natural resources, and social change.

548. Sociology of Energy (3) Social aspects of energy production, conservation, and scarcity; interrelated problems in modern society.

551. Social Stratification and Social Change (3) Origin and development of stratification systems and inequality among and within societies; social mobility; change in stratification systems.

554. Small Community Population Growth, Human Ecology, and Social Change (3) small-town population growth and ecology; images and realities of small-town life.

555. Current Research in Work and Occupation (3) Topical seminar on nature and trends of research in the sociology of work, occupations, and professions.

573. Multivariate Analysis in Social Research (3) Overview of multivariate techniques in analysis of nonexperimental data; tabular analysis, multifactor analysis of variance, multiple correlation-regression. Prerequisite: 3 credits of statistics.

574. Statistical Methods for Social Research (3) Basic concepts of statistics; linear regression; computer software; analysis of social surveys; causal inferences from nonexperimental data. Prerequisites: 3 credits of statistics, 3 credits of research methods.

575. Statistical Models for Nonexperimental Research (3) Causal models for quantitative and qualitative data; path analysis and structural equations; logistic regression; duration models. Prerequisite: SOC 574.

576. Applied Mathematical Demography (3) Survey of mathematical models used in the study of population: models of growth, survivorship, fertility, migration, stability, kinship, projection. Prerequisites: SOC 473 or ANTH 408; calculus.

583. Research Seminar in Social Psychology (3) Design and conduct of research in areas of contemporary social psychology.

584. (PSY 584) Attitude Formation and Change (3) Theory and method in research on attitude formation and change with emphasis on critical analysis. Prerequisites: SOC 403 or PSY 417; 3 credits in statistics.

585. (PSY 585) Interaction Processes Within and Between Groups (3) Interactions in personal, group, and intergroup relations; theory and observational methods. Prerequisite: SOC 403 or PSY 417.

586. (PSY 586) The Social Psychology of Social Change (3) The interaction of individual, social, and cultural determinants of group and individual change; emphasis on social movements, crowds, and audiences. Prerequisite: SOC 403 or PSY 417.

587. (PSY 587) Socialization (3) Behavioral, cognitive, developmental, symbolic, interactionist, and role theories of socialization; emphasis on current theory and research. Prerequisite: SOC 403 or PSY 417.

588. (PSY 588) The Social Organization of Attribution (3) Principles of attribution and their relevance to such topics as power relations, authority, equity, injustice, and social movements. Prerequisite: SOC 403 or PSY 417.

590. Colloquium (1-3)

596. Individual Studies (1-9)

597. Special Topics (1-9)

602. Supervised Experience in College Teaching (1-3 per semester, maximum of 6)

SOLID STATE SCIENCE (S S S)

ROBERT E. NEWNHAM, *In Charge of Graduate Programs in Solid State Science*
251 Materials Research Laboratory
814-865-1612

Degrees Conferred: Ph.D., M.S.

Senior Members of the Graduate Faculty
S. Ashok, Ph.D. (Rensselaer) *Professor of Engineering Science*
Anthony J. Barratta, Ph.D. (Brown) *Associate Professor of Nuclear Engineering*
Gerhard R. Barsch, Dr.rer.nat. (Göttingen) *Professor of Physics*
James V. Biggers, Ph.D. (Penn State) *Senior Scientist*
Leslie E. Cross, Ph.D. (Leeds) *Evan Pugh Professor of Electrical Engineering*
Mukunda B. Das, Ph.D. (London), D.I.C. *Professor of Electrical Engineering*
Steven J. Fonash, Ph.D. (Pennsylvania) *Professor of Engineering Science*
Earl K. Graham, Jr., Ph.D. (Penn State) *Professor of Geosciences*
Bruce E. Knox, Ph.D. (Penn State) *Associate Professor of Materials Science*
Jeffrey S. Lannin, Ph.D. (Stanford) *Professor of Physics*
Herbert A. McKinstry, Ph.D. (Penn State) *Associate Professor of Solid State Technology*
Russell F. Messier, Ph.D. (Penn State) *Associate Professor of Engineering Science and Mechanics*
Gary L. Messing, Ph.D. (Florida) *Associate Professor of Ceramic Science and Engineering*
Laxman N. Mulay, Ph.D. (Bombay) *Professor of Solid State Science*
Robert E. Newnham, Ph.D. (Penn State, Cambridge) *Alcoa Professor of Solid State Science*
Carlo G. Pantano, Ph.D. (Florida) *Associate Professor of Ceramic Science and Engineering*
Della M. Roy, Ph.D. (Penn State) *Professor of Materials Science*
Rustum Roy, Ph.D. (Penn State) *Evan Pugh Professor of the Solid State*
George Simkovich, Ph.D. (Penn State) *Professor of Materials Science*
Deane K. Smith, Ph.D. (Minnesota) *Professor of Mineralogy*
Karl E. Spear II, Ph.D. (Kansas) *Professor of Ceramic Science*
Vladimir Stubican, Dr. Phil. (Zagreb), D.Sc. *Professor of Ceramic Science*
Vijay K. Varadan, Ph.D. (Northwestern) *Professor of Engineering Science and Mechanics*
Vasundara V. Varadan, Ph.D. (Illinois) *Associate Professor of Engineering Science and Mechanics*
Kuppuswamy Vedam, Ph.D. (Indian Institute of Science) *Professor of Physics*
William B. White, Ph.D. (Penn State) *Professor of Geochemistry*
Christopher R. Wronski, Ph.D. (London) *Leonhard Professor of Microelectronic Devices and Materials*

Associate Members of the Graduate Faculty

James H. Adair, Ph.D. (Florida) *Assistant Professor of Ceramic Science*
Andrzej Ryszard Badzian, Ph.D. (Polish Institute of Physics) *Research Associate*
Amar S. Bhalla, Ph.D. (Penn State) *Senior Scientist and Professor of Solid State Science*
Michael W. Grutzeck, Ph.D. (Penn State) *Senior Research Associate and Associate Professor of Solid State Science*
Wayne Huebner, Ph.D. (Missouri) *Assistant Professor of Ceramic Science*
Sei Joo Jang, Ph.D. (Penn State) *Senior Research Associate and Associate Professor of Solid State Science*
Gerald G. Johnson, Jr., Ph.D. (Penn State) *Associate Professor of Computer Science*
Sridhar Komarneni, Ph.D. (Wisconsin) *Associate Professor of Clay Mineralogy*
Robert N. Pangborn, Ph.D. (Rutgers) *Associate Professor of Engineering Mechanics*
Clayton O. Ruud, Ph.D. (Denver) *Senior Research Associate*
Barry Earl Scheetz, Ph.D. (Penn State) *Senior Research Associate and Associate Professor of Solid State Science*
Thomas R. Shrout, Ph.D. (Penn State) *Research Associate and Assistant Professor of Solid State Science*

The aim of this intercollege program is to provide an opportunity for the student interested in the structure, properties, and behavior of solid materials to obtain an integrated program of courses encompassing both the necessary fundamentals of chemistry, physics, and mathematics and their technological and engineering applications.

The program of courses taken by a student majoring in this program must necessarily cut across two or more disciplines. The relevant subject matter has been grouped into four areas: (1) the structure of solids (crystal chemistry and structure determination); (2) theory related to the solid state (physics, chemistry, and mechanics); (3) properties of solids (optical, electrical, magnetic, mechanical, thermal, and chemical); and (4) reactions of solids (phase equilibria, reaction mechanisms, reaction kinetics, and surface reactions).

Admission Requirements

Scores from the Graduate Record Examination (GRE), or from a comparable substitute examination accepted by a graduate program and authorized by the dean of the Graduate School, are recommended but not required for admission. Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin*.

Entering students should hold a bachelor's degree in chemistry, physics, mathematics, geological science, engineering, ceramics, or metallurgy, or in a closely related field that will have included in it mathematics at least through integral calculus and a minimum of one year of physics and one year of chemistry. Students with a 3.00 junior/senior grade-point average and with appropriate course backgrounds will be considered for admission. Exceptions to the 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests. The applicant should be interested specifically in an interdisciplinary program of study and research.

Degree Requirements

The course work of all students normally will include the "core program" as periodically redefined. Recommended course sequences for each year for students with different undergraduate backgrounds are prepared by the chair and are available from the student's adviser.

S S S 590 (Colloquium) and S S S 596 (Individual Studies) will be offered three times each year to promote the interdisciplinary aspects of solid state science. Further information will be available from the solid state science office.

In addition, students may select appropriate course work from any engineering or science department. The following list includes those that are most commonly taken to satisfy core curriculum requirements: Structure of Solids: MATSC 430, 512, 514; Solid State Chemistry: MATSC 416, 501, 503; Properties of Materials: PHYS 412, 413, CERSC 508, MATSC 540, 542, and E E 547.

Thesis research on various aspects of the solid state may be conducted in the Materials Research Laboratory, the Applied Research Laboratory, or in appropriate departments in the Colleges of Earth and Mineral Sciences, Engineering, or Science. The experimental facilities for research in several aspects of materials science and engineering are exceptional.

The communication and foreign language requirement for the Ph.D. degree may be satisfied by intermediate knowledge of two foreign languages, or by one foreign language together with courses from other designated areas.

Student Aid
In addition to the fellowships, traineeships, graduate assistantships, and other forms of financial aid described in the STUDENT AID section of the *Graduate Bulletin*, the following awards typically have been available to graduate students in this program:

ALCOA FELLOWSHIP —Available to graduate students in solid state science.

CORNING GLASS WORKS FELLOWSHIP —Available to graduate students in solid state science.

CTS FELLOWSHIP — Available to graduate students in solid state science.

KODAK FELLOWSHIP — Available to graduate students in solid state science.

ONR FELLOWSHIP — Available to graduate students in solid state science.

PHILIPS FELLOWSHIP —Available to graduate students in solid state science.

SOLID STATE SCIENCE (S S S)

590. COLLOQUIUM (1-3)

596. INDIVIDUAL STUDIES (1-9)

SPANISH (SPAN)

LEON F. LYDAY, *Head of the Department of Spanish, Italian, and Portuguese*
N-351 Burrowes Building
814-865-4252

Degrees Conferred: Ph.D., M.A., M.Ed.

Senior Members of the Graduate Faculty
John B. Dalbor, Ph.D. (Michigan) *Professor of Spanish*
Martha T. Halsey, Ph.D. (Ohio State) *Professor of Spanish*
Robert F. Lima, Jr., Ph.D. (NYU) *Professor of Spanish and Comparative Literature*
Leon F. Lyday III, Ph.D. (North Carolina) *Professor of Spanish*
Terry J. Peavler, Ph.D. (California) *Associate Professor of Spanish and Comparative Literature*
Martin S. Stabb, Ph.D. (UCLA) *Professor of Spanish*
Alfred A. Triolo, Ph.D. (Illinois) *Associate Professor of Spanish and Italian*
Beno Weiss, Ph.D. (NYU) *Associate Professor of Italian*

Associate Members of the Graduate Faculty
Mary E. Barnard, Ph.D. (Michigan) *Assistant Professor of Spanish and Comparative Literature*
Earl E. Fitz, Ph.D. (CUNY) *Associate Professor of Portuguese, Spanish, and Comparative Literature*
Donna M. Rogers, Ph.D. (Toronto) *Assistant Professor of Spanish*

The program offers M.A. options in literature and linguistics, as well as doctoral emphasis in either of these two areas.

Admission Requirements
Scores from the Graduate Record Examination (GRE), or from a comparable substitute examination accepted by a graduate program and authorized by the dean of the Graduate School, are required for admission. At the discretion of a graduate program, a student may be admitted provisionally for graduate study in a program without these scores. Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin*.

The minimum requirement for admission normally will be 24 credits of postintermediate work in Spanish language and literature.

Students with a 3.00 junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

Degree Requirements

A candidate for the M.A. degree must take a minimum of 30 credits at the graduate level including 6 credits in a related minor field. An M.A. essay and a comprehensive written examination also are required. The M.A. degree (or equivalent) is normally a prerequisite to doctoral candidacy.

Candidates for the M.Ed. degree must take 6 credits in a field of professional education.

For the Ph.D. degree, a student must complete at least 60 credits (including M.A. credits) of graduate-level work, including a 15-credit minor. Other requirements include (1) an oral doctoral candidacy examination and a comprehensive written examination; (2) reading knowledge of two foreign languages or a comprehensive knowledge of one foreign language; and (3) a doctoral dissertation.

Student Aid

In addition to the fellowships, traineeships, graduate assistantships, and other forms of financial aid described in the STUDENT AID section of the *Graduate Bulletin,* the following awards typically have been available to graduate students in this program:

EDWIN ERLE SPARKS DISSERTATION FELLOWSHIP IN THE HUMANITIES — Available to a doctoral candidate in one of the following graduate programs: classics, comparative literature, English, French, German, history, linguistics, philosophy, religious studies, Slavic languages and literatures, Spanish, and speech communication; stipend $8,040 plus tuition. Apply to department before February 1.

EDWIN ERLE SPARKS FELLOWSHIPS IN THE HUMANITIES (8) — Available to beginning graduate students in one of the following graduate programs: classics, comparative literature, English, French, German, history, linguistics, philosophy, religious studies, Slavic languages and literatures, Spanish, and speech communication; stipends $6,740 plus tuition. Apply to department before February 1.

SPANISH (SPAN)

400. ADVANCED STYLISTICS (3)
410. ADVANCED ORAL EXPRESSION AND COMMUNICATION (3)
412. TRANSLATION (3)
414. SPANISH PHONOLOGY (3)
415. SPANISH MORPHOLOGY AND SYNTAX (3)
418. THE EVOLUTION OF SPANISH (3)
439. DON QUIJOTE (3)
440. (FR 440, IT 440) TEACHING OF ROMANCE LANGUAGES (3)
472. THE CONTEMPORARY SPANISH AMERICAN NOVEL (3)
476. MASTERPIECES OF SPANISH AMERICAN LITERATURE (3)
490. MASTERPIECES OF SPANISH PROSE (3)
491. MASTERPIECES OF SPANISH DRAMA AND POETRY (3)
496. INDEPENDENT STUDIES (1-18)
497. SPECIAL TOPICS (1-9)
499. FOREIGN STUDY — SPANISH (3)

502. THEORY AND TECHNIQUES OF TEACHING SPANISH (1-3) Audio-lingual orientation.

503. METHODS AND BIBLIOGRAPHY IN SPANISH (1-3) Methods of research; evaluation of sources and materials.

507. HISPANO-ROMANCE LINGUISTICS (3 per semester, maximum of 9) History, development, and linguistic description of Old Spanish and related Romance languages of the Iberian Peninsula. *Rogers*

510. SPANISH DESCRIPTIVE LINGUISTICS: PHONOLOGY (3) *Dalbor*

511. SPANISH TRANSFORMATIONAL-GENERATIVE LINGUISTICS (3) *Dalbor*

514. HISPANIC DIALECTOLOGY (3 per semester, maximum of 6) Early fragmentation among the peninsular dialects; their status today, Judeo-Spanish; descriptive analysis of modern Spanish American dialects. *Dalbor*

516. MEDIEVAL SPANISH LITERATURE (3 per semester, maximum of 9) Topics vary: *juglaría* and *clerecía,* emergence of lyric and brief narrative; history and didacticism; origins of novel; balladry; fifteenth-century innovations. *Rogers*

518. El Libro De Buen Amor (3)

521. The Celestina and the Literature of the Spanish Pre-Renaissance (3) Chief trends and works of the period of the Catholic monarchs, with special emphasis on Fernando de Rojas's masterpiece *La Celestina*. *Triolo*

526. Sixteenth-Century Spanish Literature (3 per semester, maximum of 9) Prose and poetry of major authors: works and trends of the Renaissance and the early Golden Age. *Triolo*

528. Seventeenth-Century Spanish Literature (3 per semester, maximum of 9) Prose and poetry of major authors: works and trends of the late Golden Age and Baroque period. *Triolo*

537. Golden Age Theatre (3 per semester, maximum of 6) Major works of Lope de Vega, Tirso de Molina, Calderón, and others.

540. Cervantes (3 per semester, maximum of 9) The literary works of Cervantes: *Don Quijote*, other novels, dramatic works, and poetry.

544. Spanish Romanticism (3) The major authors and works of peninsular romanticism, including poetry, drama, and prose. *Halsey and Lima*

550. Spanish Realism (3) The major figures of the period with special emphasis on Pérez Galdós.

553. Writings of the "Generation of 1898" (3 per semester, maximum of 6) Novels, plays, short stories, essays, poetry of Valle-Inclán, Azorín, Benavente, Unamuno, Machado, Maeztu, and Baroja in the context of generation concept. *Lima*

560. The Contemporary Novel in Spain (3) The novel since 1941: Cela, Laforet, Zunzunegui, Suárez Carreño, Matute, and others.

563. Contemporary Drama in Spain (3) The drama from 1898 to the present day: Benavente, Valle-Inclán, García Lorca, Casona, Buero Vallejo, Sastre, and others. *Halsey and Lima*

566. Contemporary Spanish Poetry (3) Various currents in Spanish poetry from the generation of 1927: Lorca, Aleixandre, Salinas, Guillén, Alonso, Alberti, Hernández, Otero, and others.

568. Early Spanish American Literature (3 per semester, maximum of 9) Content varies; selected topics from colonial period, romanticism, and the nineteenth century before modernism. *Staff*

570. Modernismo (3) The movement, its antecedents, and its followers, with special emphasis on Rubén Darío. *Staff*

574. The Spanish American Novel (3 per semester, maximum of 9) Content varies; selected works from the late nineteenth century through the contemporary period. *Peavler*

575. The Spanish American Essay (3) Tracing the history of ideas in Spanish America through major essayists. *Stabb*

576. Twentieth-Century Spanish American Poetry (3) Influential poets and literary movements after *modernismo*. *Lyday and Stabb*

577. Spanish American Drama (3) Dramatic literature in Spanish America from colonial times to the present. *Lyday*

581. The Spanish American Short Story (3) Critical analysis of the major writers and movements from Echeverría to the present. *Peavler and Stabb*

587. Stylistic and Literary Criticism (3) Major theories of literary criticism applied to Hispanic literature.

588. Seminar in Hispanic Literature (3-12) Common and individual research in special problems in Spanish or Spanish American literature.

596. Individual Studies (1-9)

597. Special Topics (1-9)

SPECIAL EDUCATION (SPLED)

G. PHILLIP CARTWRIGHT, *Department Head*
124A Moore Building
814-865-6072

Degrees Conferred: Ph.D., M.S., M.Ed.

Senior Members of the Graduate Faculty
Carol A. Cartwright, Ph.D. (Pittsburgh) *Professor of Education*
G. Phillip Cartwright, Ph.D. (Pittsburgh) *Professor of Special Education*
Joseph L. French, Ed.D. (Nebraska) *Professor of Special Education and Educational Psychology*
Anna H. Gajar, Ph.D. (Virginia) *Associate Professor of Special Education*
John T. Neisworth, Ph.D. (Pittsburgh) *Professor of Special Education*
John A. Salvia, D.Ed. (Penn State) *Professor of Special Education*
James W. Tawney, Ph.D. (Illinois) *Professor of Special Education*

Associate Members of the Graduate Faculty
Libby Goodman, Ed.D. (Temple) *Assistant Professor of Special Education*
Charles A. Hughes, Ph.D. (Florida) *Assistant Professor of Special Education*
James K. McAfee, Ph.D. (Georgia State) *Assistant Professor of Special Education*
Kathy L. Ruhl, Ph.D. (Florida) *Assistant Professor of Special Education*

Exceptional children are those who deviate so far from average in physical, intellectual, emotional, or social characteristics that they do not profit adequately from the usual public school program. It is the purpose of the M.Ed. program in Special Education to prepare teachers of exceptional children. M.Ed. students are trained in behavior management and instructional design, implementation, and evaluation appropriate for effective work with mentally retarded, gifted, emotionally disturbed, and learning-disabled children at all age levels and degrees of severity. The purpose of the M.S. and Ph.D. programs is to prepare researchers and college and university teachers in areas encompassing the education of the mentally retarded, gifted, emotionally disturbed, or learning disabled. The former program is professional in nature; the latter two, academic.

Admission Requirements

Scores from the Graduate Record Examination (GRE) or from the Miller Analogies Test (MAT) are required for admission. At the discretion of a graduate program, a student may be admitted provisionally for graduate study in a program without these scores. Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin.*

Highest admission priorities are given to applicants who possess certification in special education or elementary education. Applicants for master's and doctoral programs must present evidence of superior academic achievement, complete a personal statement, present GRE verbal and quantitative test scores, or MAT scores, and provide professional references. Minimum test scores of master's and doctoral applicants, respectively, are GRE (verbal and quantitative combined), 900 and 1100; MAT, 35 and 50. Applicants for doctoral study must have had at least two years of relevant experience with handicapped children. Applicants from foreign countries must submit TOEFL (Test of English as a Foreign Language) scores. Exceptions to the admissions criteria may be made only for highly qualified students with special backgrounds, abilities, and interests.

Master's Degree Requirements

Prerequisites for the M.Ed. program include 26 credits basic to the education of exceptional children (courses comparable to SPLED 400, 401, 454, and 395A, B, C, or D; SPLED 410, 430, or 470; C I 408; a 400-level course in child development or child psychology; and a 400-level course in foundations of education). Of the 30 credits required for the M.Ed. degree, 6 must be taken from fields outside of education; 18 must be taken in special education; and 15 must be taken at the 500 level. SPLED 411, 412, and 573 are required along with two practica: SPLED 595A and 595B. M.Ed. students must submit a master's paper and pass a comprehensive examination.

Of the 30 credits required for the M.S. degree, 6 must be taken from one discipline outside of education; 18 must be taken in special education; and 18 must be taken at the 500 level. SPLED 573 and EDPSY 400 are required as are 6 credits of thesis research, SPLED 600. M.S. students must submit a master's thesis and pass a comprehensive examination.

All requirements for either the M.Ed. or the M.S. degree, whether satisfied on the University Park Campus or elsewhere, must be met within six years or a period spanning seven consecutive summers.

Doctoral Degree Requirements

The communication and foreign language requirement for the Ph.D. degree is prescribed by each student's committee. The requirements include the successful completion of a philosophy of science course (e.g., PHIL 421) and additional language and communication abilities such as foreign language competence, computer programming skills, expertise with alternative communication systems, research publication, etc. Minimum requirements for the Ph.D. degree include 24 credits of research methods; 18 credits in a cognate area such as psychology, sociology, or child development; and 36 credits in education. The student also must enroll in SPLED 500 each semester prior to successful completion of the comprehensive examinations. A candidacy examination is required no later than the second semester of full-time study; written and oral comprehensive examinations are required following the satisfactory completion of the language requirement. A student is required to complete the program within seven years from the date of acceptance as a candidate.

Student Aid

In addition to the fellowships, traineeships, graduate assistantships, and other forms of financial aid described in the STUDENT AID section of the *Graduate Bulletin,* the following award typically has been available to graduate students in this program:

U.S. Office of Education Assistantships or Traineeships in Special Education — Open to graduate students being prepared as leadership personnel in special education; stipend varies, depending on conditions of existing grants. Other graduate assistantships also may be available. Apply to the Graduate Admissions Committee, 125 Moore Building.

SPECIAL EDUCATION (SPLED)

400. Introduction to Exceptional Children (3)
401. Educational Adjustments for Exceptional Children (3)
402. Human Rights for the Handicapped Student (2)
404. Parents as Teachers (2)
410. The Mentally Retarded (3)
411. Instruction for the Severely Handicapped (3)
412. Instruction for the Mildly Handicapped Student (3)
413. (VOCED 413) Vocational Education for Special-Needs Learners (3)
415. Early Special Education (3)
416. Assessing Exceptional Preschoolers (1)
417. Development of Individual Education Programs (1)
418. Technology Applications for Handicapped Persons (2)
420. (EDPSY 420) The Mentally Gifted (3)
430. Learning Disabilities (3)
440. (CMDIS 440) Survey of Speech and Hearing Disorders (3)
454. Diagnosis of Educational Disabilities (3)
470. The Emotionally Disturbed (3)
495A. Practicum in General Special Education (1-12)
495B. Practicum in Vocational Special Education (1-12)
495C. Practicum With Young Handicapped Children (1-12)
495D. Practicum With Severely Handicapped Children (1-12)
496. Independent Studies (1-18)
497. Special Topics (1-9)

500. Seminar in Special Education (1-9) Continuing series of professional seminars designed to provide a forum for discussion of current and classical research concerning exceptional children. Prerequisites: EDPSY 400; 6 credits in special education.

501. Administration and Supervision of Educational Programs for Exceptional Children (2-3) Problems connected with the instituting and organizing of classes for atypical children; the legal phases, finances, teaching personnel, pupil personnel, housing, equipment, courses of study, curriculum, etc. Prerequisites: SPLED 401 and EDADM 480, or teaching or administrative or supervisory experience.

510. Problems in the Education of the Mentally Retarded (2-4) Study of existing curricula, instructional practices, educational programs; experimentation in curriculum building and materials construction. Prerequisites: teaching experience and SPLED 410.

520. (EDPSY 520) Problems in the Education of the Mentally Gifted (2-4) Analysis of educational needs of the mentally gifted; curriculum construction and curricular materials. Prerequisites: SPLED (EDPSY) 420, teaching experience.

530. Problems in the Education of the Learning Disabled (2-4) Review of the research and theoretical implications in the educational and behavioral management of learning disabled children. Prerequisite: SPLED 430.

547. (CMDIS 547) Language Disorders in Children (2) Nature, etiology, diagnosis, and management of language disorders in children. Prerequisites: CMDIS 400; 6 credits in communication disorders or related fields such as psychology, linguistics, or human development.

555. Curriculum-Based Assessment for Handicapped Learners (2) Development and use of diagnostic procedures for planning and evaluating instructional programs for handicapped pupils. Prerequisites: SPLED 454; SPLED 105 or 400.

569. Educating the Autistic Child (2) Behavioral characteristics, etiology, and treatment emphasizing attention, social interaction, discrimination, self-injurious and self-stimulatory behavior, and language. Prerequisites: SPLED 401, 470.

570. Problems in the Education of the Emotionally Disturbed (2-4) Prerequisite: SPLED 470.

573. Problems of Research with Handicapped Groups (2) A seminar to review and design research studies for the education and training of handicapped groups. Prerequisite or concurrent: SPLED 454.

595A. Practicum (1-6) Supervised clinical experience on campus in University-managed diagnostic and remedial settings.

595B. Field Experiences in Off-Campus Laboratories (1-10) Supervised off-campus field experiences in selected laboratory settings with exceptional children. Prerequisite: SPLED 595A.

595C. Internship in Special Education Supervision (1-6) Internship in day/residential school setting under supervision of field supervisor and University faculty. Prerequisite: SPLED 595B.

595D. Internship in Special Education (2-10) Internship to take place in schools or educational situations where student is not regularly employed, under supervision of graduate faculty. Prerequisite: SPLED 495A or 495B or 495C or 495D or teaching experience.

596. Individual Studies (1-9)

597. Special Topics (1-9)

602. Supervised Experience in College Teaching (1-3 per semester, maximum of 6)

SPEECH COMMUNICATION (SPCOM)

DENNIS S. GOURAN, *Head of the Department*
212 Sparks Building
814-865-3461

Degrees Conferred: Ph.D., M.A.

Senior Members of the Graduate Faculty
Thomas W. Benson, Ph.D. (Cornell) *Professor of Speech Communication*
Herman Cohen, Ph.D. (Iowa) *Professor of Speech Communication*
Dennis S. Gouran, Ph.D. (Iowa) *Professor of Speech Communication*
Richard B. Gregg, Ph.D. (Pittsburgh) *Professor of Speech Communication*
Gerard A. Hauser, Ph.D. (Wisconsin) *Associate Professor of Speech Communication*
Gerald M. Phillips, Ph.D. (Case Western Reserve) *Professor of Speech Communication*

Associate Members of the Graduate Faculty
Deborah F. Atwater, Ph.D. (SUNY-Buffalo) *Associate Professor of Speech Communication*
David E. Butt, D.Ed. (Penn State) *Associate Professor of Speech Communication*
J. Louis Campbell III, Ph.D. (Minnesota) *Assistant Professor of Speech Communication*
Robert E. Dunham, Ph.D. (Ohio State) *Professor of Speech Communication*
Patricia A. Dunkel, Ph.D. (Arizona) *Assistant Professor of Speech Communication*
Christopher L. Johnstone, Ph.D. (Wisconsin) *Associate Professor of Speech Communication*

Tony M. Lentz, Ph.D. (Michigan) *Assistant Professor of Speech Communication*
Joyce Neu, Ph.D. (Southern California-Los Angeles) *Assistant Professor of Speech Communication*
Douglas J. Pedersen, D.Ed. (Penn State) *Associate Professor of Speech Communication*
Deborah M. Rekart, Ph.D. (Louisiana State) *Assistant Professor of Speech Communication*
Judith L. Stephens, Ph.D. (Kent State) *Associate Professor of Speech Communication*
Arden K. Watson, Ed.D. (Vanderbilt) *Assistant Professor of Speech Communication*
Molly Wetheimer, Ph.D. (Penn State) *Assistant Professor of Speech Communication*
Gaynelle Winograd, Ph.D. (Colorado) *Assistant Professor of Speech Communication*
Hal Witteman, Ph.D. (Wisconsin) *Assistant Professor of Speech Communication*
Nancy J. Wyatt, Ph.D. (Penn State) *Assistant Professor of Speech Communication*

Students may specialize in communication theory, English as a second language, oral interpretation, organizational communication, rhetorical theory and criticism, small group and interpersonal communication, speech education, speech science, and telecommunication.

Admission Requirements

Scores from the Graduate Record Examination (GRE) are required for admission. Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin*.

The minimum undergraduate preparation is 12 credits in speech. Students who cannot meet this requirement in full may be admitted but must make up their deficiencies without credit toward the graduate degree.

Additionally, students with a 3.00 junior-senior average and appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests. Students must have completed the master's degree before being admitted as a doctoral candidate.

Master's Degree Requirements

A total of 30 credits, including 6 for the thesis, is required for the M.A. in Speech Communication. A thesis is required of all M.A. candidates in this major. SPCOM 420 or 440 is required of all graduate students who do not have their equivalent. Master's candidates must schedule a review of their program of courses during their first year of residence. Master's candidates must schedule a proposal meeting at which the research plan for their thesis is approved by their committee. Master's candidates are required to present an oral defense of their thesis before their committee.

Doctoral Degree Requirements

The communication and foreign language requirement for the Ph.D. degree may be satisfied by options selected from designated areas including, but not restricted to, foreign languages. SPCOM 420 or 435 or 440 is required of all graduate students who do not have their equivalent. Doctoral candidates must schedule a candidacy evaluation during their first year. Following completion of the language requirement, doctoral candidates must take a comprehensive examination to determine their mastery and competence in speech communication. Doctoral candidates must schedule a proposal meeting at which the research plan for their dissertation is approved by their committee. Doctoral candidates must present a final oral defense of their dissertation before their committee.

Student Aid

In addition to the fellowships, traineeships, graduate assistantships, and other forms of financial aid described in the STUDENT AID section of the *Graduate Bulletin,* the following awards typically have been available to graduate students in this program:

Edwin Erle Sparks Dissertation Fellowship in the Humanities — Available to a doctoral candidate in one of the following graduate programs: classics, comparative literature, English, French, German, history, linguistics, philosophy, religious studies, Slavic languages and literatures, Spanish, and speech communication; stipend $8,040 plus tuition. Apply to department before February 1.

Edwin Erle Sparks Fellowships in the Humanities (8) — Available to beginning graduate students in one of the following graduate programs: classics, comparative literature, English, French, German, history, linguistics, philosophy, religious studies, Slavic languages and literatures, Spanish, and speech communication; stipends $6,740 plus tuition. Apply to department before February 1.

SPEECH COMMUNICATION (SPCOM)

*114G. Basic English as a Second Language (3) Instruction in English as a second language for international students that focuses on basic aspects of English reading, writing, listening, and speaking skills.

*115G. English as a Second Language: Speaking and Listening (3-9) English as a second language focusing on speaking and listening skills.

*116G. English as a Second Language: Reading and Writing (3-9) English as a second language for graduate students; focusing on reading and writing skills.

*117G. English as a Second Language for Teaching Assistants (3-9) English as a second language for preparation of international teaching assistants. Prerequisite: SPCOM 115G, with a grade of A or TSE score of 200.

*118G. English as a Second Language for Teaching Assistants II (3) Advanced course in English as a second language for preparation of international teaching assistants. Prerequisite: SPCOM 117G or TSE score of 229+.

400. Speech Communication Training in Business (3)
401. Speech Communication Research Methods (3)
402. Speech and Human Behavior (3)
403. Interpersonal Oral Communication Theory (3)
410. American-English Phonetics (3)
412. Speech Criticism (3)
413. (LING 413) Experimental Linguistics (3)
414. Speech Science (3)
415. Rhetoric of Film and Television (3)
420. Systems and Theories of Rhetoric (3)
426. Communication and Responsibility (3)
431. Anatomy and Physiology of the Vocal Mechanism (3)
437. Television Programming and Performance (3)
438. Rhetoric of Documentary (3)
440. Systems and Theories of Human Communication (3)
450. Group Communication Theory (3)
452. Organizational Communication (3)
455. Gender Roles in Communication (3)
460. Foundations of Rhetorical Theory (3)
470. Nonverbal Communication (3)
475. Studies in Public Persuasion (3)
478. Contemporary American Political Rhetoric (3)
480. Oral Tradition of Interpretation (3)
481. (L A 481) Computer Applications to Communications Studies (3)
482. (LING 482) Introduction to Applied Linguistics (3)
484. Linguistic Structures for English as a Second Language (3)
485. Advanced Oral Interpretation of Literature (3)
490. Psychology of Speaking and Listening (3)
491. Theory: Second Language Acquisition (3)
492. Development of Communication Behavior in Children (3)
493. Teaching of English as a Second Language (3)
494. Research Topics (1-12)
495. Communication Internship (1-18)
496. Independent Studies (1-18)
497. Special Topics (1-9)
499. Foreign Study — Speech Communication (1-9)

500. Seminar in Historical Criticism (2-6) Application of principles of rhetorical criticism to significant oral communications of the past.

501. (COMM 501) Proseminar in Mass Communications (3 per semester) Overview of paradigms in mass communications research. Prerequisite: admission to doctoral program.

*No graduate credit is given for this course.

502. Communication Theory and Research (3) Research design, thesis proposals, and background for research in graduate study. Prerequisites: 6 credits at the 400 or 500 level in speech communication, clinical speech, or theatre arts.

503. Seminar in Criticism (3 per semester, maximum of 6) Study of philosophies and methods available for the critical analysis of rhetorical transactions. Prerequisite: SPCOM 412.

505. Historical Development of Rhetorical Theory (3 per semester, maximum of 9) Study of one or more periods of rhetorical theory from Greek antiquity to 1900. Prerequisite: SPCOM 420.

506. Contemporary Rhetorical Theory (3 per semester, maximum of 6) A study of rhetorical theory from 1930 to the present, focusing on semantic, political, sociological, symbolic, and philosophical perspectives. Prerequisites: SPCOM 412, 505.

507. Seminar in Rhetorical Theory Building (3-6) Investigation of selected frameworks for explaining rhetorical phenomena; examination of underlying assumptions; application to theory building in rhetoric. Prerequisite: SPCOM 420 or 460.

509. Problems in Rhetoric and Communication (3-12) Theoretical, analytical, and critical problems of human communication, with application of humanistic and social scientific research framework. Prerequisites: 6 credits in speech communication.

510. Problems in Speech Education (2-4) Advanced knowledge, theories, and principles, together with their philosophical, scientific, clinical, artistic, and educational implications for the teacher of speech. Prerequisites: SPCOM 502 and 9 additional credits at the 400 or 500 level in speech communication, clinical speech, or theatre arts.

515. Seminar in Rhetoric and Media (3) Seminar in the application of rhetorical theory and criticism to special problems of communication in television, film, and other media.

520. Seminar in Speech Science (3-6) Seminar in physical and physiological bases of speech and voice; introduction to laboratory techniques used in speech research. Prerequisites: 9 credits in speech communication, speech pathology and audiology, or psychology.

522. (CMDIS 522) Speech Perception (3) Transformation of linguistic units into acoustic speech signals, theories of speech perception, and auditory processing of the speech signal. Prerequisites: SPCOM 410, 431, 520.

530. Political Communication and Media (3) Study of rhetorical and communicative dimensions of contemporary political communication with particular attention to electronic media.

540. Seminar in Telecommunications (3) Study of the historical and contemporary issues and problems in telecommunications.

550. Seminar in Oral Persuasion (3 per semester, maximum of 6) Theory and devices of persuasion; analysis of persuasive discourse. Prerequisites: 6 credits in speech communication including SPCOM 100.

551. (LING 551) Linguistic Analysis of a Non-Indo-European Language (3) An investigation into the phonological, morphological, syntactic, and discourse structures of a selected non-Indo-European language. Prerequisite: LING 400 or 403 or SPCOM 484.

552. Oral Communication in Industry, Business, and Government (2-4) Needs, practices, and methods in American industry, business, and government; methods of training adults in oral communications skills.

554. Seminar in Small Group Communication (3 per semester, maximum of 6) Communication variables in small groups. Experimental research and innovations in communication in vocational, therapeutic, and educational groups.

555. Seminar in Interpersonal Communication (3 per semester, maximum of 6) Investigation of the communicative management of ongoing relationships; examination of how communication both creates and responds to exigencies of friendship. Prerequisite: SPCOM 403 or 440.

570. Seminar in Nonverbal Communication (3) An advanced seminar for students planning to teach or do research in human nonverbal communication. Prerequisite: SPCOM 470.

571. Cross-Cultural Communication (3) Detailed investigation into cross-cultural communication, focusing on differences in systems and potential areas of miscommunication. Prerequisite: SPCOM 470 or 491 or 493.

581. Discourse Analysis in ESL (English as a Second Language) (3) An inquiry into the role of context on the form and meaning of linguistic structures from an ESL perspective. Prerequisites: SPCOM 491, 493.

590. Colloquium (1-3)

591. Seminar in Second Language Acquisition (3) Advanced research in theoretical and experimental issues in second language acquisition. Prerequisite: SPCOM 491.

593. Research Problems in English as a Second Language (3) A detailed investigation into specific areas of research in English as a second language. Prerequisite: SPCOM 493.

594. Research Topics (1-12) Supervised student activities on research projects identified on an individual or small group basis. Prerequisite: prior approval of proposed assignment by instructor.

595. Internship (1-9)

596. Individual Studies (1-9)

597. Special Topics (1-9)

602. Supervised Experience in College Teaching (1-3 per semester, maximum of 6)

STATISTICS (STAT)

THOMAS P. HETTMANSPERGER, *Head of the Department*
219 Pond Laboratory
814-865-1348

Degrees Conferred: Ph.D., M.S., M.A.

Senior Members of the Graduate Faculty
Michael G. Akritas, Ph.D. (Wisconsin) *Associate Professor of Statistics*
Charles E. Antle, Ph.D. (Oklahoma State) *Professor of Statistics*
Steven F. Arnold, Ph.D. (Stanford) *Associate Professor of Statistics*
Gutti J. Babu, Ph.D. (India) *Professor of Statistics*
Clifford C. Clogg, Ph.D. (Chicago) *Professor of Sociology and Statistics*
Frank A. Haight, Ph.D. (New Zealand) *Professor of Statistics and Transportation*
William L. Harkness, Ph.D. (Michigan State) *Professor of Statistics*
Thomas P. Hettmansperger, Ph.D. (Iowa) *Professor of Statistics*
Robert A. Hultquist, Ph.D. (Oklahoma State) *Professor of Statistics*
Walter K. Kremers, Ph.D. (Cornell) *Assistant Professor of Statistics*
Bruce G. Lindsay, Ph.D. (Washington) *Professor of Statistics*
J. Keith Ord, Ph.D. (London) *Professor of Statistics and Management Science*
Ganapati P. Patil, Ph.D., D.Sc. (Michigan) *Professor of Mathematical Statistics*
James L. Rosenberger, Ph.D. (Cornell) *Associate Professor of Statistics*
Thomas A. Ryan, Jr., Ph.D. (Cornell) *Associate Professor of Statistics*

Associate Members of the Graduate Faculty
Marllyn T. Boswell, Ph.D. (California-Riverside) *Assistant Professor of Statistics*
Stavros Kourouklis, Ph.D. (Rutgers) *Assistant Professor of Statistics*

Graduate instruction and research opportunities are available in most areas of statistics and probability, including linear models, nonparametric statistics, robustness, statistical computing, analysis of count data, multivariate analysis, experimental design, reliability, stochastic processes and probability (applied and theoretical), distribution theory, statistical ecology, and biometrics.

Graduate students can gain practical experience in the application of statistical methodology through participation in the department's statistical consulting and collaborative research activities. For course credit, students can participate in statistical consulting with researchers (graduate students, staff, and faculty) in other departments. In addition, collaborative projects with other departments provide longer term experience and support for selected students.

Most students gain valuable teaching experience by assisting in the teaching and grading of courses. In addition, Ph.D. candidates with proper qualifications can receive support for teaching undergraduate courses.

Admission Requirements

Scores from the Graduate Record Examination (GRE), or from a comparable substitute examination accepted by a graduate program and authorized by the dean of the Graduate School, are optional for admission. Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin*.

While applications from all students (including those who already have done graduate work) are reviewed, completion of a standard calculus sequence is regarded as a prerequisite. Students with a 3.00 or better junior-senior average and with appropriate course backgrounds will be considered for admission. The best-qualified applicants will be accepted up to the number of spaces that are available for new students. Exceptions to the minimum 3.00 grade-point average may be made for students with special backgrounds, abilities, and interests.

Entering graduate students in statistics for whom English is not the first language are required to have a score of at least 550 on the TOEFL (Test of English as a Foreign Language) examination. The results of this examination must be received by the Department of Statistics at least six months prior to the requested date of admission to the Graduate School.

Degree Requirements

For the M.A. degree the candidate must complete 30 course credits, with at least 24 credits (18 in statistics) of 500-level courses; 3 credits in probability (STAT 513); 4 credits in mathematical statistics (STAT 514); 3 credits in stochastic processes (STAT 515); MATH 441 or 436; 3 credits in seminars and/or individual studies; and 6 credits in an approved area. In addition, the M.A. candidate must submit a master's paper. The requirements for the M.S. degree are the same as for the M.A. except that 6 credits of thesis research replace an equal number of course credits, and a thesis is required rather than a master's paper.

The department administers a qualifying examination that each student must take after the first year. This written examination must be passed as a requirement for the master's degree and, in addition, superior performance on this examination is used by the department to recommend students for Ph.D. candidacy.

A written comprehensive examination, administered by the department, must be taken by each Ph.D. candidate after two or three years of course work. This is followed by an oral examination, as required by the Graduate School, under the supervision of the student's graduate committee. The oral examination typically coincides with initiation of the doctoral thesis research. After the thesis is written, the student and thesis adviser schedule the oral defense, the final examination for the Ph.D. degree. There is no foreign language requirement for the Ph.D. in Statistics.

Other Relevant Information

Students in the Statistics program may elect the dual-title degree program option in Operations Research for the Ph.D. and M.S. degrees (see p. 326).

Student Aid

Graduate assistantships available to students in this program and other forms of student aid are described in the STUDENT AID section of the *Graduate Bulletin*. GRE scores are required for consideration for assistantships.

STATISTICS (STAT)

401. Experimental Methods (3)
409. (MATH 409) Mathematical Statistics I (3)
410. (MATH 410) Mathematical Statistics II (3)
414. (MATH 414) Introduction to Probability Theory (3)
415. (MATH 415) Introduction to Mathematical Statistics (4)
416. (MATH 416) Stochastic Modeling (3)
418. Discrete Probability Theory (3)
451. Introduction to Applied Statistics (3)
460. Intermediate Applied Statistics (3)
462. Applied Regression Analysis (3)
464. Applied Nonparametric Statistics (3)
480. Introduction to Statistical Program Packages (1)
496. Independent Studies (1-18)
497. Special Topics (1-9)

501. Regression Methods (3) Analysis of research data through simple and multiple regression and correlation; polynomial models; indicator variables; step-wise, piece-wise, and logistic regression. Prerequisite: 6 credits of statistics or STAT 451; matrix algebra.

502. Analysis of Variance and Design of Experiments (3) Analysis of variance and design concepts; factorial, nested, and unbalanced data; ANCOVA; blocked, Latin square, split-plot, repeated measures designs. Prerequisite: STAT 462 or 501.

503. Design of Experiments (3) Design principles; optimality; confounding in split-plot, repeated measures, fractional factorial, response surface, and balanced/partially balanced incomplete block designs. Prerequisites: STAT 502; STAT 462 or 501.

504. Analysis of Discrete Data (3) Models for frequency arrays; goodness-of-fit tests; two-, three-, and higher-way tables; latent and logistics models. Prerequisites: STAT 460 or 502 or 512; matrix algebra.

505. Applied Multivariate Statistical Analysis (3) Analysis of multivariate data; T^2-tests; partial correlation; discrimination; MANOVA; cluster analysis; regression; growth curves; factor analysis; principal components; canonical correlations. Prerequisites: 6 credits in statistics; matrix algebra.

506. Sampling Theory and Methods (3) Theory and application of sampling from finite populations. Prerequisites: calculus; 3 credits in statistics.

508. Applied Statistical Distribution Theory (3) Analysis of data involving nonnormal families of distributions; model building and selection, parameterizations, inferential algorithms, transformations, simulations, displays, interpretations. Prerequisite: STAT 401 or 409.

510. Applied Time Series Analysis (3) Identification of models for empirical data collected over time. Use of models in forecasting. Prerequisite: STAT 462 or 501 or 511.

511. Regression Analysis and Modeling (3) Multiple regression methodology using matrix notation; linear, polynomial, and nonlinear models; indicator variable; AOV models; piece-wise regression, autocorrelation; residual analyses. Prerequisite: STAT 451 or 6 credits of statistics; matrix algebra, calculus.

512. Design and Analysis of Experiments (3) AOV, unbalanced, nested factors; CRD, RCBD, Latin squares, split-plot, and repeated measures; incomplete block, fractional factorial, response surface designs; confounding. Prerequisite: STAT 511.

513. Theory of Statistics I (3) Probability models, random-variables, expectation, generating functions, distribution theory, limit theorems, parametric families, exponential families, sampling distributions. Prerequisite: MATH 230.

514. Theory of Statistics II (3) Sufficiency, completeness, likelihood, estimation, testing, decision theory, Bayesian inference, sequential procedures, multivariate distributions and inference, nonparametric inference. Prerequisite: STAT 513.

515. Stochastic Processes I (3) Conditional probability and expectation, Markov chains, the exponential distribution and Poisson processes. Prerequisite: MATH 414 (STAT 414) or STAT 513.

516. (MATH 516) Stochastic Processes (3) Markov chains; generating functions; limit theorems; continuous time and renewal processes; martingales, submartingales, and supermartingales; diffusion processes; applications. Prerequisite: STAT (MATH) 416.

517. (MATH 517) Probability Theory (3) Measure theoretic foundation of probability, distribution functions and laws, types of convergence, central limit problem, conditional probability, special topics. Prerequisite: MATH 501.

518. (MATH 518) Probability Theory (3) Measure theoretic foundation of probability, distribution functions and laws, types of convergence, central limit problem, conditional probability, special topics. Prerequisite: MATH 517.

519. (MATH 519) Topics in Stochastic Processes (3) Selected topics in stochastic processes, including Markov and Wiener processes; stochastic integrals, optimization, and control; optimal filtering. Prerequisites: STAT (MATH) 516, 517.

524. Ecometrics (3) Stochastic models and statistical methods in ecological problems; population dynamics, spatial patterns in populations of one, two, or more species. Prerequisite: STAT (MATH) 414 or STAT 418.

525. Biostatistics (3) Medical experimentation and epidemiological studies; retrospective and prospective studies; design of clinical trials; clinical trials; models for censored survival data. Prerequisite: STAT 501 or 511.

527. (BIOL 527) Quantitative Ecology (3) Introduction to quantitative population and community ecology, with emphasis on problems, concepts, and methods using mathematical, statistical, and computational analysis. Prerequisites: STAT (MATH) 409, BIOL 210.

528. (BIOL 528) Statistical Ecology Spectrum (3) Overview of research and instruction of particular interest to quantitative ecology faculty in the Ecology program. Prerequisite: STAT (BIOL) 527.

534. (M E R 534) Dynamic Programming (3) The study of the concepts underlying model-building and optimization of dynamic systems; applications to engineering, economic, and environmental systems. Prerequisites: STAT (MATH) 414; I E 405 or Q B A 451.

540. Statistical Computing (3) Computational foundations of statistics; algorithms for linear and nonlinear models, discrete algorithms in statistics, graphics, missing data, Monte Carlo techniques. Prerequisites: STAT (MATH) 415; STAT 501 or 511; matrix algebra.

544. Theory of Contingency Tables (3) Theory of multidimensional contingency tables; maximum likelihood estimation, sufficiency, testing, asymptotics, complete and incomplete factorial tables, quantal response models. Prerequisites: STAT (MATH) 410 or 415; STAT 502 or 512.

548. Statistical Distribution Theory (3) Analytical study of nonnormal models and methods in reliability theory, survival analysis, records evaluation, scale/scale-free analysis, and directional statistics. Prerequisite: STAT (MATH) 410 or 414 or 416.

551. Linear Models I (3) A coordinate-free treatment of the theory of univariate linear models, including multiple regression and analysis of variance models. Prerequisites: MATH 415 (STAT 415) or STAT 514; STAT 512; MATH 436 or MATH 441.

552. Linear Models II (3) Treatment of other normal models, including generalized linear, repeated measures, random effects, mixed, correlation, and some multivariate models. Prerequisite: STAT 551.

561. Statistical Inference I (3) Multiparameter estimation; linear estimation; maximum likelihood estimation; Bayesian estimation; large sample properties and procedures. Prerequisite: STAT 514.

562. Statistical Inference II (3) Testing statistical composite hypotheses; invariance principles; Bayesian statistics; large sample properties and procedures. Prerequisite: STAT 561.

564. Theory of Nonparametric Statistics (3) Estimation and testing based on nonparametric procedures for location and regression models. Distribution theory and asymptotic efficiency. Prerequisite: MATH 415 (STAT 415) or STAT 514.

565. Multivariate Analysis (3) Theoretical treatment of methods for analyzing multivariate data, including Hotelling's T2, MANOVA, discrimination, principal components, and canonical analysis. Prerequisites: STAT 505, 551.

572. Statistical Decision Theory I (3) Structure of statistical games, optimal strategies, fixed sample-size games. Prerequisite: MATH 415 (STAT 415) or STAT 514.

580. Statistical Consulting Practicum (2 per semester, maximum of 10) General principles of statistical consulting and statistical consulting experience. Preparation of reports and other aspects of consulting. Prerequisites: STAT 502; STAT 503 or 504 or 505.

590. Colloquium (1-3)

596. Individual Studies (1-9)

597. Special Topics (1-9)

TEACHING AND CURRICULUM (T & C)

DONALD K. ALEXANDER, *Coordinator of the Graduate Program in Teaching and Curriculum*
Penn State Harrisburg, The Capital College
Middletown, PA 17057
717-948-6208

Degree Conferred: M.Ed.

Senior Members of the Graduate Faculty
Frank J. Swetz, Ed.D. (Columbia) *Professor of Mathematics and Education*
Kathryn Towns, Ph.D. (Penn State) *Associate Professor of Educational Psychology*

Associate Members of the Graduate Faculty
Donald K. Alexander, Ph.D. (Indiana State) *Associate Professor of Education*
Richard I. Ammon, D.Ed. (Penn State) *Assistant Professor of Education*
Steven M. Barnes, Ph.D. (Michigan State) *Assistant Professor of Education*
William A. Henk, Ed.D. (West Virginia) *Assistant Professor of Education and Reading*
Betty C. Holmes, Ph.D. (Texas) *Assistant Professor of Education and Reading*
John H. Joseph, Ph.D. (Penn State) *Affiliate Assistant Professor of Education*
Robert J. Lesniak, Ph.D . (Syracuse) *Associate Professor of Education*
Stanley M. Miller, Ed.D. (George Peabody) *Professor of Social Sciences and Education*
Jacob L. Susskind, Ph.D. (George Peabody) *Assistant Professor of Social Sciences and Education*

The Master of Education in Teaching and Curriculum at Penn State Harrisburg provides to full-time and part-time students a curriculum designed to develop master teachers for public and private school instruction and education specialists (teaching certification not required) for the areas of business, industry, government, medicine, and other social services. In addition, specialities are available in particular areas, such as reading, urban education curriculum, early childhood education, elementary education, and secondary English, social studies, and mathematics education.

Specifically, the goals of the program are to develop in students (1) the ability to communicate effectively either with school-age students and their parents or with coworkers and/or clients; (2) the ability to conduct an instructional program that provides a sound intellectual and emotional climate for learning; (3) competence in a variety of teaching methods and in the utilization of materials and content appropriate for an effective instructional program; (4) the ability to interpret and to evaluate educational literature and research; and (5) the ability to describe and to evaluate major issues and current trends in instructional curriculum practice and development.

Certification programs are also available in the areas of reading specialist (K-12) and private nursery school teaching.

Admission Requirements
Scores from the Graduate Record Examination (GRE) are required for applicants with grade-point averages below 3.00. For dates, locations, and other information about the test, call the Counseling Center at Penn State Harrisburg, telephone 717-948-6025, or write to the Educational Testing Service, Graduate Record Examination, Princeton, NJ 08540. Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin*.

An applicant must present a baccalaureate degree from an accredited institution with a junior-senior grade-point average of 2.50. Exceptions may be made for students with special backgrounds, abilities, and interests.

An applicant whose original language is not English is required to submit acceptable scores on the Test of English as a Foreign Language (TOEFL). A score of 550 is required. The scores must be submitted before the application will be considered.

Degree Requirements
Courses appropriate for a desired objective will be selected by the student and his or her adviser. After acceptance to the Graduate School, the student, with the adviser, will prepare a proposed list of requirements for the completion of the degree. This list, upon approval of the division head or a designated representative, will constitute the student's degree program, subject to annual review or review at the request of the student, the adviser, the program coordinator, or the division head.

For graduates of education undergraduate programs, a total of 36 credits of work normally will be required. Graduates of other undergraduate programs usually complete substantially more work to satisfy the requirements for this degree. Some of this additional work may include undergraduate courses. Program requirements include 3 credits in foundations of education. Each student will be expected to complete from one-third to two-thirds of the work in courses other than education courses. A minimum of 12 credits in 500-level courses must be completed. The last 12 credits in a student's program must be earned at Penn State Harrisburg.

A maximum of 10 credits may be transferred into this program. However, students who transfer from the University Park Campus will have their credits evaluated on an individual basis. All transfer credits must be approved in writing by the student's adviser.

Each individual completing the Master of Education degree will be required to write a master's paper or complete a master's production or practicum. The proposal for this project must be presented to the professor selected to supervise the work and must be approved at least one full semester before the semester in which the student completes the requirements for the degree. The master's project must be written under the guidance and direction of the student's committee. Papers written as course requirements will not be acceptable as master's papers. The committee must approve the final draft of the master's project by the first day of classes of the semester in which the student expects to graduate.

A minimum grade-point average of 3.00 for work done at the University is required for graduation.

Student Aid

Graduate assistantships available through this program and other forms of student aid are described in the STUDENT AID section of the *Graduate Bulletin*.

EDUCATION (EDUC)

505. Curriculum Foundations (3) Study of the philosophical, cultural, social, and human developmental sources and implications of the school curriculum.

506. Curriculum Development (3) Examination of theory, issues, organization, and local school problems of curriculum development.

560. Classroom Management (3) Analysis of teaching styles, classroom behavior and interaction, organization and correlation of classroom activities and subject areas. (Requires practical application in an actual teaching situation.)

561. Psychology of Reading (3) Examination of the theoretical bases for reading which have direct practical implication for teaching reading. Prerequisites: EDUC 314, 321.

562. Diagnostic Evaluation of Reading Problems (3) Utilization of formal and informal instruments and techniques appropriate in analyzing reading disabilities, grades K through 12; includes practicum. Prerequisite: EDUC 321.

563. Advanced Methods in Teaching Reading (3) Advanced development of diagnostic and instructional techniqes for teaching reading, with emphasis on individual and small group instruction. Prerequisite: EDUC 321.

564. Reading Clinic (3-6) A practicum course in which students display their competencies in working with children possessing reading problems. Prerequisites: EDUC 421, 422, 423, 561, 562, 563, BE SC 405, 406.

571. Great Teachers (3) Study of one or more great teachers, e.g., Socrates, Comenius, Locke, Rousseau, Pestalozzi, Herbart, Froebel, Dewey, Kilpatrick.

572. Comparative Education: World Perspectives (3) An evaluative comparison of American education with Western and non-Western educational systems.

583. Problems in Teaching: Selected Subject Areas (3) An analysis of a teaching problem with review of research literature to seek solutions to that problem. Prerequisite: consent of adviser.

584. Analysis of Research: Selected Topics (3) A review and analysis of research in a specified area. Prerequisite: EDUC 586 or consent of adviser.

586. Educational Research Designs (3) Identification of research designs appropriate to educational field and laboratory investigations and the development of a master's project proposal. Prerequisites: 15 credits in graduate study.

587. Master's Project (3) The development of an original master's project (paper, essay, production, practicum) supervised and judged by an appropriate faculty committee. Prerequisite: consent of adviser.

589. Problems in Urban Education (3) Independent study of selected topics related to urban education.

590. Colloquium (1-3)

591. Education Seminar (1-6) Seminars in important, and often controversial, topics in education.

596. Individual Studies (1-9)

597. Special Topics (1-9)

TEACHING ENGLISH AS A SECOND LANGUAGE (TESL)

DENNIS S. GOURAN, *Head, Department of Speech Communication*
213 Sparks Building
814-865-3461

Degree Conferred: M.A.

Senior Members of the Graduate Faculty
Eunice Askov, Ph.D. (Wisconsin) *Professor of Education*
Philip Baldi, Ph.D. (Rochester) *Professor of Linguistics*
Stephen Beckerman, Ph.D. (New Mexico) *Assistant Professor of Anthropology*
Frank DiVesta, Ph.D. (Cornell) *Professor of Education and Psychology*
Juris Draguns, Ph.D. (Rochester) *Professor of Psychology*
Thomas Hale, Ph.D. (Rochester) *Associate Professor of French and Comparative Literature*
Warren Morrill, Ph.D. (Chicago) *Professor of Anthropology*
Keith Nelson, Ph.D. (Yale) *Professor of Psychology*
David Palermo, Ph.D. (Iowa) *Professor of Psychology*
Joseph Prewitt-Diáz, Ph.D. (Connecticut) *Associate Professor of Education*
Philip Prinz, D.Ed. (Boston) *Associate Professor of Communication Disorders*

Associate Members of the Graduate Faculty
Jeannette Bragger, Ph.D. (California-Santa Barbara) *Associate Professor of French*
Barton Browning, Ph.D. (California-Berkeley) *Associate Professor of German*
Avigail Vicente, Doc. de 3^{e} Cycle (Paris) *Assistant Professor of French*
Ellen Woolford, Ph.D. (Duke) *Assistant Professor of Anthropology and Linguistics*

The master's program in Teaching English as a Second Language is an interdisciplinary program utilizing faculty and course resources of the Departments of Anthropology; Educational Psychology; English; French; German; Linguistics; Reading, Communication, and Language Education; Psychology; and Speech Communication. The program is designed to prepare competent teachers of English as a second language. The program is problem focused, integrating content from the fields of language structure, composition, communication, and learning theory. No thesis is required; however, a master's paper and a comprehensive examination are prescribed. It is expected that graduates of the program will be employed overseas and in English learning centers in the United States.

Completion of this degree program does not qualify the student for a Pennsylvania Teacher Certificate.

Admission Requirements
Scores from the Graduate Record Examination (GRE) are required for admission. Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin*.

Applicants whose native language is not English must submit a TOEFL score of 600 or better with their applications. Students with a 3.00 junior-senior average and with appropriate course backgrounds will be admitted up to the number of spaces available.

Degree Requirements
The M.A. in TESL requires 36 credits, of which 18 credits must consist of 500-level courses. In lieu of a thesis, students must prepare a master's paper and pass a comprehensive examination. The following courses are prescribed for a total of 27 credits: 12 credits from SPCOM 491, 493, SPCOM 571 or RCLED 544, SPCOM 595; 9 credits from LING 400, 403, and 450; 6-9 credits from EDPSY 421 or RCLED 450, RCLED 540, 544, 560, 566, or INSYS 415.

Student Aid
Graduate assistantships that may be available to students in this program and other forms of student aid are described in the STUDENT AID section of the *Graduate Bulletin.*

THEATRE ARTS (THEA)

DOUGLAS N. COOK, *In Charge of Graduate Programs in Theatre Arts*
103 Arts Building
814-865-7586

Degrees Conferred: M.A., M.F.A.

Senior Members of the Graduate Faculty
William H. Allison, M.F.A. (Yale) *Professor of Theatre Arts*
Lowell L. Manfull, Ph.D. (Minnesota) *Professor of Theatre Arts*

Associate Members of the Graduate Faculty
John R. Bayless, M.F.A. (Penn State) *Assistant Professor of Theatre Arts*
Douglas N. Cook, M.A. (Stanford) *Professor of Theatre Arts*
William E. Crocken *Associate Professor of Theatre Arts*
Charles H. Firmin, M.F.A. (Penn State) *Assistant Professor of Theatre Arts*
Anne A. Gibson, M.F.A. (Carnegie-Mellon) *Professor of Theatre Arts*
William J. Kelley, M.F.A. (Penn State) *Associate Professor of Theatre Arts*
Barry M. Kur, M.A. (SUNY) *Assistant Professor of Theatre Arts*
Robert E. Leonard, M.F.A. (Goodman School of Drama) *Associate Professor of Theatre Arts*
Douglas R. Maddox, M.F.A. (Carnegie Tech.) *Associate Professor of Theatre Arts*
Helen A. Manfull, Ph.D. (Minnesota) *Professor of Theatre Arts*
Douglas R. Marme, M.F.A. (Brandeis) *Assistant Professor of Theatre Arts*
Thomas P. McNally, M.F.A. (Denver) *Associate Professor of Theatre Arts*
Albert J. Pertalion, M.F.A. (Louisiana State) *Associate Professor of Theatre Arts*

This program pursues the following objectives: (1) to assist each student in acquiring discriminating taste and critical judgment in theatre arts; (2) to help each student attain skills and proficiencies in theatre arts; (3) to provide the training, discipline, and opportunities essential to the development of a professional ability in at least one area of theatre arts; and (4) to prepare each student for an active career in academic, professional, and/or community theatre.

Department facilities include the Playhouse, a 450-seat proscenium thrust theatre, the Pavilion, a 249-seat arena or three-quarter theatre; theatre production studios for scenic, property, and costume preparation; a lighting laboratory; a sound and media studio; a makeup studio; and rehearsal and dance studios. Adjunct facilities include the 2600-seat Eisenhower Auditorium, the 1000-seat Schwab Auditorium, and the 550-seat Recital Hall.

Admission Requirements
Graduate Record Examination (GRE) scores, or comparable examination scores, are not required for admission to the Department of Theatre Arts. If available, however, these scores may be submitted as supplemental information for use in evaluating a candidate's application for admission. Requirements listed below are in addition to general Graduate School requirements stated in the *Graduate Bulletin.*

Requirements for admission to the M.A. and M.F.A. programs are (1) a broad undergraduate preparation in theatre, including 3 credits each in acting, directing, stagecraft, and theatre history; and 6 credits of dramatic literature; (2) 12 credits in related subject areas such as communications, oral interpretation, art, business, music, and dance; and (3) submission of a vita and at least three letters of recommendation.

Additional requirements for M.F.A. candidates are (1) submission of evidence of professional potential in the proposed area of specialization — auditions, prompt books, portfolios, manuscripts, and other appropriate presentations — to the applicable study program(s) by arrangement with the department; and (2) a personal interview to be arranged by the student.

Diagnostic examinations in the areas of theatre history and criticism and in dramatic literature are administered during the first semester of study. Students found to be substantially deficient may be required to take additional course work in the area(s) of deficiency without receiving graduate degree credit.

Master of Arts Degree Requirements

The program is designed to prepare the student for (1) professional employment as a teacher of theatre arts on the secondary or junior college level; (2) critical study and research in preparation for the pursuit of a related doctorate or professional degree; and (3) related professional work in industry, business, or the arts. Two areas of study are required: general theatre (history, theory, criticism, dramatic literature, and research) and practical theatre (directing, design, management, children's theatre, playwriting, and technical theatre). M.A. candidates are required to participate in University Resident Theatre Company productions in positions of responsibility. Generally, an M.A. program requires a minimum of three to four semesters in residence.

A minimum of 42 credits must be earned in the program. The master's candidate must prepare either a thesis or two scholarly papers. If a student elects to write a thesis, 6 of those credits will be earned as part of the thesis process. A student electing scholarly papers will submit, for program approval, two master's papers to testify to the student's research and writing ability. Each master's paper should be equivalent in scope to a graduate seminar research project. Both the thesis or the papers must be in style and analytic quality of approved graduate form and quality.

Master of Fine Arts Degree Requirements

The program entails specialized professional training in one of the following areas: acting; directing; scene design; costume design; costuming; lighting design and technology; technical direction; theatre management; or playwriting. Six semesters in residence are normally required to complete the minimum 60-credit degree.

Students are evaluated on a semester-by-semester basis on academic progress, creative achievement, and professional potential. The M.F.A. is a professional degree and is granted by the Graduate Faculty on the basis of academic and creative excellence over and above the fulfillment of requirements. Satisfactory academic progress does not guarantee continuance in the program, nor does continuance in the program imply the automatic granting of a degree. M.F.A. candidates are required to participate in University Resident Theatre Company productions in positions of responsibility. Additionally, each student must complete a committee-approved monograph project in the area of specialization.

Student Aid

Graduate assistantships available to students in this program and other forms of student aid are described in the STUDENT AID section of the *Graduate Bulletin*.

THEATRE ARTS (THEA)

400. Advanced Theatre Projects (1-6)
401. Theatre History I: Ancient to 1700 (3)
402. Theatre History II: From 1700 to Present (3)
405. Theatre History: American Theatre (3)
409. Fundamentals of Creative Performance for Classroom Teachers (3)
420. Acting VI (3)
421. Acting VII (3)
422. Advanced Voice and Speech I (2)
423. Advanced Voice and Speech II (2)
424. Advanced Movement and Dance for the Actor I (2)
425. Advanced Movement and Dance for the Actor II (2)
426. Children's Theatre (3)
427. Theatre Makeup (2)
428. Creative Drama (3)
429. Theatre Performance Practicum (1-3 per semester)
430. Acting Professionally (3)

434. Directing (3)
435. Advanced Script Analysis and Fundamentals of Staging (3)
436. Projects in Directing (1)
440. Principles of Playwriting (3)
445. Advanced Playwriting (3-6)
450. Scenic Design II (3 per semester, maximum of 6)
453. Advanced Scene Painting (1-2 per semester, maximum of 6)
457. Scene Design for Production (1 per semester, maximum of 6)
460. Costume Design II (3)
461. Costume Construction II (3)
466. Costume Construction for Production (1 per semester, maximum of 6)
467. Costume Design for Production (1 per semester, maximum of 6)
470. Lighting Design II (3)
477. Lighting Design for Production (1 per semester, maximum of 6)
480. Technical Production II (3)
481. Stage and Production Management (3)
485. Sound for Theatre Production (3)
487. Technical Projects for Production (1 per semester, maximum of 6)
489. Theatre Production Practicum (1-6 per semester, maximum of 12)
495. Internship Practicum (1-6 per semester, maximum of 12)
496. Independent Studies (1-18)
497. Special Topics (1-9)

500. Theatre Research: Sources and Procedure (3) Source materials and techniques as applied to theatre research; the form and content of theses and monographs.

503. Theatre Criticism and Theory (3) Graduate seminar in examination and application of major dramatic and critical theories from Aristotle to present. Prerequisite: THEA 500.

504. Acting and Directing Theory (3) The actor and director as related to the cultural environment from the Greek theatre through the post-Stanislavskian theorists. Prerequisite: THEA 500.

505. Theatre History (3) Specific aspects of theatre from ancient times to the present.

520A. Acting I (3) Exercises, monologue, and scene study. Principal focus on realism. Prerequisite: admission to the MFA performance acting program.

520B. Movement for Actors I (2) Techniques and skills in physical expression, awareness, control, and stage movement. Prerequisite: admission to MFA performance acting program.

520C. Voice and Speech I (2) Vocal techniques for the actor: articulation, voice control, support, and projection. Prerequisite: admission to the MFA performance acting program.

521A. Acting II (3) A continuation of THEA 520A. Prerequisites: THEA 520A, 520B, 520C.

521B. Movement for Actors II (2) A continuation of THEA 520B. Prerequisites: THEA 520A, 520B, 520C.

521C. Voice and Speech II (2) A continuation of THEA 520C. Prerequisites: THEA 520A, 520B, 520C.

522. Graduate Acting III (3) Advanced exercises, monologue and scene study. Principal focus on nonrealistic material. Prerequisite: THEA 521.

523. Graduate Acting IV (3) A continuation of THEA 522. Prerequisite: THEA 522.

524. Advanced Movement and Dance for the Actor I (2) Advanced techniques and skills in physical expression, period movement, and theatre dance. Prerequisite: THEA 521.

525. Advanced Movement and Dance for the Actor II (2) A continuation of THEA 524. Prerequisite: THEA 524.

526. Advanced Voice and Speech I (2) Advanced voice and speech training for the actor: articulation, resonance, stage dialects, scansion of verse drama. Prerequisite: THEA 521.

527. Advanced Voice and Speech II (2) A continuation of THEA 526. Prerequisite: THEA 526.

528. Acting Professionally (3) Orientation to the professional theatre: development of audition repertoire, unions, rounds, interviews, and survey of acting profession. Prerequisite: THEA 523.

530. Rehearsal Methods for the Director (3) Theory and practice in approaches, procedures, and techniques in mounting a play. Prerequisites: THEA 434, 435, permission of instructor prior to registration.

531. Directorial Styles and Approaches (1) Seminar in advanced theory and directorial practice. Designed for the advanced student of directing. Prerequisite: THEA 530.

532. Directing Seminar (1) Career orientation for the director: résumé preparation, interviewing, unions, and survey of directorial opportunities. Prerequisite: THEA 531.

533. Projects in Directing (1-2) Approved directing projects for the M.F.A. directing student. Prerequisites: THEA 435; admission to the M.F.A. directing program.

540. Playwriting (3-6) Focus on problems in writing the full-length script through seminar, play reading, and individual session.

543. Projects in Playwriting (1-9) Preparation of the script for revision during and following production of the student's original play. Prerequisite: production approval.

550. Scenic Design III (3 per semester, maximum of 9) Advanced design; concentration on conceptualization, visual communication skills, portfolio production. Prerequisites: THEA 450; portfolio review.

551. Scenic Design IV (1-6) Advanced projects in scenic design. Prerequisite: THEA 550 or portfolio review.

557. Scenic Design for Production (1 per semester, maximum of 6) Design and execution of production design projects. Prerequisite: approval of proposed project by instructor prior to registration.

560. Costume Design III (3 per semester, maximum of 9) Advanced costume design with emphasis on total production concept. Prerequisite: THEA 460 or portfolio review.

561. Costume Design and Construction (1-6) Advanced special projects for the graduate designer and costumer. Prerequisites: THEA 461 or 560; approval of proposed project by instructor prior to registration.

564. History of Costume (3) Exploration of dress from Egyptian to modern. Prerequisite: permission of instructor prior to registration.

566. Costume Construction for Production (1 per semester, maximum of 6) Execution of production in construction and shop management. Prerequisite: approval of proposed project by instructor prior to registration.

567. Costume Design for Production (1 per semester, maximum of 6) Design and execution of production design projects. Prerequisite: approval of proposed project by instructor prior to registration.

570. Stage Lighting Design III (3) Advanced techniques in the art of theatrical lighting design. Prerequisite: THEA 470.

577. Lighting Design for Production (1 per semester, maximum of 6) Design and execution of production design projects. Prerequisite: approval of proposed project by instructor prior to registration.

580. Technical Production III (3) Design consultation and specification of equipment, systems, and movable structures for new theatres; structures and projection devices for production. Prerequisite: THEA 480.

581. Theatre Administration I (3) Organizational structure and personnel; contracts; unions; budget preparation and control; administrative styles in theatre, opera, and dance. Prerequisite: THEA 481.

582. Theatre Administration II (3) Fund raising; promotion; audience development; audience survey technique; program development and strategies. Prerequisite: THEA 581.

583. Projects in Theatre Administration, Management, and Operations (1-6)

584. Performing Arts Facility Management (3) Management practices in theatres, auditoriums, and arts complexes; environmental systems; acoustical considerations; programming and community relations. Prerequisite: THEA 481.

585. Theatre Planning (3) Processes and problems in planning and designing theatres: performance, audience, and technical requirements.

587. Technical Projects for Production (1 per semester, maximum of 6) Execution of assigned technical projects for theatre production. Prerequisite: approval of proposed project by instructor prior to registration.

590. Colloquium (1-3)

591. Special Problems in Film and TV (1-3 per semester)

595. Internship (1-3) Professional field experience in theatre performance, production, and management assignments. Prerequisite: approval of internship by instructor prior to registration.

596. Individual Studies (1-6)

597. Special Topics (1-6)

602. Supervised Experience in College Teaching (1-3 per semester, maximum of 6)

TRAINING AND DEVELOPMENT (TRDEV)

ROBERT J. LESNIAK, *In Charge of the Graduate Program in Training and Development*
Penn State Harrisburg, The Capital College
Middletown, PA 17057
717-948-6213

Degree Conferred: M.Ed.

Senior Member of the Graduate Faculty
Kathryn L. Towns, Ph.D. (Penn State) *Associate Professor of Educational Psychology*

Associate Members of the Graduate Faculty
Donald K. Alexander, Ph.D. (Indiana State) *Associate Professor of Education*
Steven M. Barnes, Ph.D. (Michigan State) *Assistant Professor of Education*
Daniel D. Flannery, Ph.D. (Wisconsin) *Assistant Professor of Education*
William A. Henk, Ed.D. (West Virginia) *Assistant Professor of Education and Reading*
Betty C. Holmes, Ph.D. (Texas) *Assistant Professor of Education and Reading*
John H. Joseph, Ph.D. (Penn State) *Assistant Professor of Educational Technology and Multi-Media Journalism*
Robert J. Lesniak, Ph.D. (Syracuse) *Associate Professor of Education*
Stanley N. Miller, Ed.D. (George Peabody) *Professor of Social Science and Education*
Jacob L. Susskind, Ph.D. (George Peabody) *Assistant Professor of Social Science and Education*

The Master of Education in Training and Development at Penn State Harrisburg provides to full- and part-time students a curriculum designed to prepare adult trainers for industry, government, and health care institutions. Graduates may assume positions in organizations that utilize instruction, program planning and evaluation, and development of instructional sequences for new employees, employees changing jobs, or employees who must learn new procedures.

The specific goals of the program are to develop in students the ability to assess training needs and develop a structured training process with predefined outcomes; to evaluate a training program; to prepare training materials; to facilitate group discussions and group processes; to translate learning needs into objectives and learning activities; to design and test theories and practices related to training and development; to evaluate and carry out research; and to describe common organizational structures found in business and industry, government, and medicine and how the training role relates to these structures.

Admission Requirements
Scores from the Graduate Record Examination (GRE) may be required for applicants with low grade-point averages. Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin*.

An applicant must present a baccalaureate degree from an accredited institution with a junior-senior grade-point average of 2.50 or higher. Exceptions may be made for students with special backgrounds, abilities, and interests.

Entering graduate students for whom English is not the first language are required to have a score of 550 or higher on the Test of English as a Foreign Language (TOEFL). The scores must be submitted before the application will be considered.

Degree Requirements

Students are required to take a total of 36 credits for the degree. Of this total, 18 credits must be taken from the following courses: TRDEV 418, 460, 497, EDUC 586, P ADM 500, and one course from EDUC 439, 506, or TRDEV 507. The remaining 18 credits are to be selected as follows: 6 credits from EDUC or TRDEV in addition to the courses listed above; and 12 credits from areas outside of EDUC or TRDEV in order to define a specific training role such as media writer or to fit the needs of the student as determined by the student and the adviser.

If a student does not have experience in a training and development position, he or she must complete a 3-credit internship, which will not count toward the 36 credits required for the degree.

A maximum of 10 credits that have been taken elsewhere but that have been determined to be applicable to the degree may be transferred to the program. The last 12 credits must be completed at Penn State Harrisburg.

Student Aid

Graduate assistantships available through this program and other forms of student aid are described in the STUDENT AID section of the *Graduate Bulletin*. GRE scores are required for candidates applying for assistantships.

COURSES

EDUC 439. Measurement and Evaluation (3)
TRDEV 418. Instructional Methods in Training and Development (3)
TRDEV 460. Foundations in Training and Development (3)
TRDEV 495. Internship in Training and Development (3-9)
TRDEV 497. Special Topics (1-9)

EDUC 506. Curriculum Development and Instructional Design (3) Examination of theory, issues, organization, and problems of curriculum development and instructional designs.

EDUC 586. Educational Research Designs (3) Identification of research designs appropriate to educational field and laboratory investigations and the development of a master's project proposal. Prerequisites: 15 credits in graduate study.

P ADM 500. Public Organization and Management (3) Development of public administration; administrative theory and practice in public organizations.

TRDEV 507. Program Evaluation (3) Evaluation of educational and other human services programs; preparation and presentation of the evaluation proposal.

TRDEV 531. Technology in Training (3) Introduction to the applications of various new instructional technologies to training problems.

TRDEV 587. Master's Paper (1-6) The development of an original master's project (paper, production, or practicum) supervised and judged by an appropriate faculty committee.

TRDEV 596. Individual Studies (1-9)

TRDEV 597. Special Topics (1-9)

VETERINARY SCIENCE (V SC)

D. L. SIMMONS, *Head of the Department*
115 W. L. Henning Building
814-865-7697

Degrees Conferred: Ph.D., M.S.

Senior Members of the Graduate Faculty
Robert J. Eberhart, D.V.M., Ph.D. (Penn State) *Professor of Veterinary Science*
Frederick G. Ferguson, D.V.M., Ph.D. (Pennsylvania) *Professor of Veterinary Science*
C. Channa Reddy, Ph.D. (Indian Inst. of Sci.) *Associate Professor of Veterinary Science*
Hansjakob Rothenbacher, D.V.M., Ph.D. (Michigan State) *Professor of Veterinary Science*
Richard W. Scholz, Ph.D. (Purdue) *Professor of Veterinary Science*
Arian Zarkower, D.V.M., Ph.D. (Cornell) *Professor of Veterinary Science*

Associate Members of the Graduate Faculty
Barrett S. Cowen, Ph.D. (Cornell) *Associate Professor of Veterinary Science*
Lester C. Griel, M.S., D.V.M. (Pennsylvania) *Associate Professor of Veterinary Science*
B. Anne Hobbs, D.V.M. (Georgia) *Assistant Professor of Veterinary Science*
J. F. Kavanaugh, D.V.M. (Cornell) *Professor of Veterinary Science*
William H. Patton, D.V.M., Ph.D. (Wisconsin) *Assistant Professor of Veterinary Science*
Richard A. Wilson, Ph.D. (Montana State) *Associate Professor of Veterinary Science*

The graduate program in Veterinary Science is designed to provide flexibility in graduate work while providing opportunities to study immunology, microbiology, animal nutrition, veterinary pathology, physiology, or toxicology, usually as related to problems seen in domestic animals.

Graduate instruction is directed by graduate faculty members from the Department of Veterinary Science and related units including dairy and animal science, biochemistry, biology, biophysics, immunology, animal nutrition, physiology, zoology, and others. The Ph.D. program is designed for completion in three to four academic years. Doctoral candidates usually complete certain required courses and obtain laboratory experience before selecting an area of specialization and completing an original research problem, including the defense of the Ph.D. dissertation.

Facilities for departmental research include laboratories in Animal Industries Building, Poultry Disease Laboratory, Animal Disease Laboratory, Centralized Biological Laboratory, and Center for Air Environment Studies. Opportunities to utilize specialized research equipment exist in other related facilities. The University has an extensive, modern library. A large University Computer Center and consultation service are available.

Admission Requirements
Scores from the Graduate Record Examination (GRE), or from a comparable substitute examination accepted by a graduate program and authorized by the dean of the Graduate School, are required for admission. At the discretion of a graduate program, a student may be admitted provisionally for graduate study in a program without these scores. Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin*.

Applicants with a 3.00 or better grade-point average and appropriate course backgrounds will be considered for admission. Applicants should have a baccalaureate degree in biological science or a degree as a graduate veterinarian or equivalent. Undergraduate preparation should include biology, chemistry, physics, mathematics through calculus, and preferably biostatistics and biochemistry.

Students generally progress from M.S. to the Ph.D. program; however, in special cases well-qualified students may be admitted directly into the Ph.D. program.

Master's Degree Requirements
A minimum of 30 graduate credits is required for the M.S. degree. Satisfactory completion of the following three courses or their equivalent is required of all degree candidates: AG 400, Biometry, 3 credits; BIOCH 401, General Biochemistry, 3 credits; BIOCH 402, General Biochemistry, 3 credits.

All graduate students are required to complete one semester of V SC 590 (Colloquium) each year as well as 8 credits from a list of courses. At least 18 credits must be taken in 500- and 600-level courses.

Veterinary Science requires no program-specific qualifying examinations, and there is no communication/language requirement for the M.S.

A thesis is required of all candidates for the M.S. degree.

Doctoral Degree Requirements

The communication requirement for the Ph.D. may be satisfied by completion of one of three options: (1) demonstrating in a foreign language competence equivalent to a level normally attained by obtaining a grade of B or better in at least two undergraduate courses in a foreign language approved by the student's committee, or by passing a reading proficiency examination given by a foreign language department; (2) demonstrating competence in scientific writing by obtaining a grade of B or better in two technical writing courses, ENGL 218 (Technical Writing) and ENGL 418 (Advanced Technical Writing and Editing); (3) demonstrating a working knowledge of computer science as applied to biologic systems by obtaining a grade of B or better in at least two 400- or 500-level courses in computer science. The communication requirement must be completed before the comprehensive examination is taken.

Satisfactory completion of the following three courses or their equivalent is required of all degree candidates: AG 400, Biometry, 3 credits; BIOCH 401, General Biochemistry, 3 credits; BIOCH 402, General Biochemistry, 3 credits. All Ph.D. candidates are required to complete one semester of V SC 590 (Colloquium) each year, at least two 400- or 500-level courses in statistics, and 8 credits from a list of courses. Certain rules regarding course level and type (course work and research) apply.

A candidacy examination is given to students entering the Ph.D. program and after completing at least twelve hours of postbaccalaureate course work.

Other Relevant Information

After a student has been admitted to graduate study in the department, an adviser will be appointed by the department head. This person may be a member of the eventual M.S. committee or someone else assigned the responsibility for directing the student's scheduling of course work. In the case of a doctoral candidate, the person may be a member of the eventual doctoral committee or someone else designated the responsibility for directing the student's scheduling of course work. The adviser is also responsible for initiating the scheduling of the candidacy examination.

Student Aid

Graduate assistantships available to students in this program and other forms of student aid are described in the STUDENT AID section of the *Graduate Bulletin*.

VETERINARY SCIENCE (V SC)

401. Anatomy of Livestock (3)
402. (ENT 402) Biology of Animal Parasites (3)
405. Laboratory Animal Science (3) *Harkness*
407. Dairy Herd Health Programs (2)
418. Methods of Animal Cell Culture (3) *Patton*
420. General Animal Pathology (3) *Rothenbacher*
496. Independent Studies (1-18)

514. (NUTRN 514) Prostaglandins and Leukotrienes (3) Biochemical, physiological, and nutritional aspects of arachidonic acid and related essential fatty acid metabolism. Structure-activity relationships of prostaglandins, prostacyclins, thromboxanes, and leukotrienes. Prerequisite: BIOCH 402 or BIOCH 437.

525. Mechanisms of Hypersensitivity and Immunopathology (3) Concepts of hypersensitivity and special consideration of immunopathological conditions. Prerequisites: BIOL 437, MICRB 410; 3 credits in pathology. *Zarkower and Ferguson*

528. Diagnostic Pathology (3-9) Gross examination of animals and birds, their tissues and body fluids for pathologic changes. Prerequisites: 6 credits in pathology, microbiology, or infectious diseases. *Card*

550. Experimental Animal Surgery (3) Principles of surgical preparation of experimental animal models for biological research, including aseptic procedures, anesthesia, surgical techniques, and aftercare. Prerequisites: BIOL 042, 421; V SC 405. *Kavanaugh*

590. Colloquium (1-3)

596. Individual Studies (1-9)

602. Supervised Experience in College Teaching (1-3 per semester, maximum of 6)

VOCATIONAL EDUCATION (VOCED)

SUSAN F. WEIS, *In Charge of Graduate Programs in Vocational Education*
212 Rackley Building
814-863-3858

Degrees Conferred: Ph.D., D.Ed.

Senior Members of the Graduate Faculty
Samuel Curtis, D.Ed. (Penn State) *Professor of Agricultural Education*
Thomas E. Long, D.Ed. (Penn State) *Professor of Vocational Education and Counselor Education*
Gene M. Love, Ph.D. (Penn State) *Professor of Agricultural Education*
James H. Mortensen, Ph.D. (Penn State) *Associate Professor of Agricultural Education*
David L. Passmore, Ph.D. (Minnesota) *Professor of Vocational Education*
Beverly Richards, D.Ed. (Penn State) *Associate Professor of Vocational Education*
Dennis C. Scanlon, Ph.D. (Penn State) *Assistant Professor of Agricultural Education*
Richard F. Stinson, Ph.D. (Ohio State) *Professor of Agricultural Education*
Susan F. Weis, Ph.D. (Penn State) *Associate Professor of Home Economics Education*
Frederick G. Welch, D.Ed. (Penn State) *Professor of Vocational Education*
Edgar P. Yoder, Ph.D. (Ohio State) *Associate Professor of Agricultural Education*

Associate Members of the Graduate Faculty
Connie Baggett, Ph.D. (Penn State) *Assistant Professor of Agricultural Education*
Joy Cantrell, Ph.D. (Mississippi State) *Assistant Professor of Agricultural and Extension Education*
Donald E. Evans, D.Ed. (Penn State) *Associate Professor of Agricultural Education*
Gary D. Geroy, Ph.D. (Minnesota) *Assistant Professor of Vocational Industrial Education*
Kenneth C. Gray, Ed.D. (Virginia Polytechnic) *Associate Professor of Vocational Education*
James W. Hilton, Ph.D. (Iowa State) *Associate Professor of Agricultural Engineering and Education*
William Williams, D.Ed. (Penn State) *Associate Professor of Agricultural Education*

This intercollege program, crossing fields within vocational education, prepares graduates for positions in local school districts, vocational technical schools, community colleges, four-year colleges and universities, and state departments of education, with emphasis in administration and supervision, research, teacher education, curriculum development and design, cooperative education, corrections education, and industrial training.

A minimum of 45 credits is required in the major, to be divided among vocational education, general professional education, and social and behavioral science courses. A minor program of study is required for the D.Ed. degree and is optional for the Ph.D. degree, and may be developed within one of five social and behavioral science options, in general studies, or in other areas approved by the candidate's committee.

The communication and foreign language requirement for the Ph.D. degree may be satisfied from nine options, which include foreign languages, computer science, statistics, technical writing, and philosophic thought.

Admission Requirements
Scores from the Graduate Record Examination (GRE), or from a comparable substitute examination accepted by a graduate program and authorized by the dean of the Graduate School, are required for admission. At the discretion of a graduate program, a student may be admitted provisionally for graduate study in a program without these scores. Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin*.

For admission, students must have a master's degree. Either the master's degree or the bachelor's degree must be in a vocational education specialization, or the applicant must have professional experience in vocational education.

Other Relevant Information
Courses appropriate to these degrees taught in the three participating departments are AG ED 418, 420, 424, 426, 434, 501, 502, 508, 509, 520, 521, 524, 530, 590, 596; I ED 402, 408, 409, 415, 427, 446, 450, 501, 506, 510, 550, 556, 557, 558, 559, 560; HE ED 406, 477, 478, 481, 482, 503, 504, 510, 518, 521, 577.

Student Aid
Graduate assistantships available to students in this program and other forms of student aid are described in the STUDENT AID section of the *Graduate Bulletin*.

VOCATIONAL EDUCATION (VOCED)

413. (SPLED 413) Vocational Education for Special-Needs Learners (3)
417. (CN ED 417) Career Education: Origins, Theory, Implementation (3)
496. Independent Studies (1-18)
497. Special Topics (1-9)

500. Philosophy of Vocational Education (3) Influence of legislative, economic, and social-psychological developments on the status and role of public vocational education in the United States.

508. Administration of Vocational Education (3) Concepts, strategies in administration of vocational programs in comprehensive high schools, area vocational technical schools, proprietary schools, and colleges.

590. Colloquium (1-3)

595. Internship (1-10) Internship at cooperating school, governmental agency, or research institution, under supervision of graduate faculty. Prerequisites: admission to candidacy and completion of 15 credits in residence beyond master's degree.

596. Individual Studies (1-9)

597. Special Topics (1-9)

VOCATIONAL INDUSTRIAL EDUCATION (VI ED)

FREDERICK G. WELCH, *In Charge of Graduate Programs in Vocational Education*
119 Rackley Building
814-863-0802

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Senior Members of the Graduate Faculty
Thomas E. Long, D.Ed. (Penn State) *Professor of Vocational Education and Counselor Education*
David L. Passmore, Ph.D. (Minnesota) *Professor of Vocational Education*
Beverly Richards, D.Ed. (Penn State) *Associate Professor of Vocational Education*
Frederick G. Welch, D.Ed. (Penn State) *Associate Professor of Vocational Education*

Associate Members of the Graduate Faculty
Wayne L. Detwiler, Sr., D.Ed. (Penn State) *Assistant Professor of Vocational Education*
Gary D. Geroy, Ph.D. (Minnesota) *Assistant Professor of Vocational Industrial Education*
Kenneth C. Gray, Ed.D. (Virginia Polytechnic) *Associate Professor of Education*

Emphasis may be placed upon preparation for teaching, supervision, administration, research, teacher education, or training in industry. The primary focus of the program is preparation for entry into responsible positions within the broadly conceived field of vocational industrial education and industrial technology.

Admission Requirements
Scores from the Graduate Record Examination (GRE) are not required for admission but may be submitted. Requirements listed below are in addition to general Graduate School requirements stated in the GENERAL INFORMATION section of the *Graduate Bulletin*.

Admission will be based on evaluation of the candidate's grade-point average, educational experiences, work experiences, and letters of recommendation. Persons admitted must have successfully completed a B.S. degree with a 2.50 grade-point average in vocational industrial education or fields related to vocational, safety, or technical education, or health occupations. Two years or more of experience in vocational industrial education, industrial training, military technical training, or work

experience in an occupation related to vocational industrial education, industrial training, vocational education, health occupations, safety education, or technical education are also required for admission. Exceptions to the minimum 2.50 grade-point average may be made for students with special backgrounds, abilities, and interests.

Degree Requirements

The communication and foreign language requirement for the Ph.D. degree may be met by the successful completion of selected courses in statistics and computer programming.

Student Aid

Graduate assistantships available to students in this program and other forms of student aid are described in the STUDENT AID section of the *Graduate Bulletin*.

INDUSTRIAL EDUCATION (I ED)

402. Supervision of Vocational Education (3)
408. Occupations (3)
409. Tests and Measurements (3)
415. Problems in Coordinating Vocational Education (3)
427. Advanced Course of Study Building (3)
446. Improvement of Instruction in Vocational Education and Training (3)
450. Shop Layout and Management (3)
471. Training in Industry and Business (3)
495A. Cooperative Education Practicum (2)
495B. Training Internship in Industry and Business (1-6)
496. Independent Studies (1-18)
497. Special Topics (1-9)

501. Seminar in Vocational Education (6) Conferences, investigations, and discussion for advanced students and mature persons who have had experience as teachers, supervisors, or administrators.

518. Program Planning for Vocational Administratrs (3) Conducting occupational surveys, directing the development of curricula, and program evaluation in vocational education. Prerequisite: three years of professional experience in vocational education.

528. Fiscal and Facilities Management for Vocational Administrators (3) Sources of revenue, budget preparation, purchasing, and the management of physical facilities in vocational education. Prerequisite: three years of professional experience in vocational education.

538. Administering Personnel Services in Vocational Education (3) Planning and implementing staff development activities, student guidance services, admissions, student organizations, and placement. Prerequisite: three years of professional experience in vocational education.

550. Research in Vocational Education (3) Research techniques in vocational industrial education.

556. Federal Legislation (2-3) Recent federal legislative activities and executive orders that bear directly and indirectly upon industrial education.

557. Present-Day Local, Personnel, and Curriculum Problems (2-3) Various plans, techniques, and practices.

559. Vocational Technical Education (2-3, Problems of organization and administration of programs of technical education at the secondary and postsecondary levels. Prerequisites: 6 credits in industrial education, valid director's certificate, or equivalent training and experience.

560. Philosophy of Industrial Education (3) Principles and beliefs of progressive industrial education; literature for evaluating instructional practices. Prerequisites: 12 credits in industrial education or teaching experience.

572. Organizational Development for Industrial Trainers (3) An introduction to major concepts, skills, and techniques required by industrial trainers to support and facilitate organizational change. Prerequisite: I ED 471.

573. Needs Assessment for Industrial Trainers (3) Acquire skills to identify training and development needs, distinguish problems with management versus training solutions, develop and evaluate training solutions. Prerequisites: I ED 471, 572.

574. Strategic Planning for Education for Work (3) Study of human capital as a component of education, industrial, and business training strategic planning at economy and organizational levels. Prerequisites: I ED 471, 572, 573.

575. Current Policy and Practices in Industrial Training (3) Analysis of training and development practices and their articulation with business practices. Prerequisites: I ED 471, 572.

576. International and Cross-Cultural Training (3) Study of concepts, models, and techniques of international training and development for industrial trainers. Prerequisites: I ED 471, 572, 574.

590. Industrial Training Professional Seminars (1) Study of special topics relating to problems, practices, methodologies, and special competency needs in industrial training. Prerequisites: I ED 471, 572.

595. Internship (2-15) Supervised study with an administrator or researcher at a cooperating school, state governmental agency, or research institution.

595A. Field-Based Project in Industrial Training (3) Students identify a training and/or organizational development problem in industry and/or business and carry out contract problem analysis and resolutions. Prerequisites: I ED 471, 572, 574.

596. Individual Studies (1-9)

597. Special Topics (1-9)

VOCATIONAL INDUSTRIAL EDUCATION (VI ED)

602. Supervised Experience in College Teaching (1-3 per semester, maximum of 6)

WILDLIFE MANAGEMENT — See FISH AND WILDLIFE SCIENCES

OTHER COURSES AND OPTIONS CARRYING GRADUATE CREDIT

The following courses are interdisciplinary or in fields in which graduate major work is not offered at Penn State. The courses, however, carry graduate credit and, with the approval of the major department head or program chair, may be applied toward the requirements for a degree either as elective courses or as a part of a general studies program. The usual restrictions upon the use of 400-series courses in degree programs apply to these courses.

AGRICULTURE, GENERAL (AG)

400. Biometry/Statistics in the Life Sciences (4)

AMERICAN STUDIES

402. American Themes, American Eras (3-6)
405. Ethnicity and the American Experience (3)
410. Early Pennsylvania Decorative Arts and Furniture (3)
415. Nineteenth-Century Pennsylvania Architecture and Restoration (3)
493. The Folktale in American Literature (3)
496. Independent Studies (1-18)
497. Special Topics (1-9)

501. Theory and Methods of American Studies (3) Theory and methods for the analysis of American culture: history of ideas, analysis of myth and symbol, comparative arts, etc.

502. Problems in American Studies (3-6) A variable-content course addressed each semester to a specific problem, topic, or period in American culture.

596. Individual Studies (1-9)

BEHAVIORAL SCIENCE (BEHSC)

508. Experimental Design (2) A graduate-level course in experimental design and analysis.

529. (NEURO 529) Neural Bases of Behavior (2) Study of neural mechanisms that control an organism's interaction with the external environment. Prerequisite: PSIO 509 or NEURO 509. Prerequisite or concurrent: ANAT 511 or NEURO 511.

596. Individual Studies (1-9)

597. Special Topics (1-9)

BLACK STUDIES

Students who want to take courses in black studies may select from the following: BL ST 400, 401; C LIT 422, 423; CN ED 554; EDTHP 404, 411; EX SC 412; FR 458; GEOG 444; HIST 479; I F S 579; PL SC 453, 454; PORT 456; RCLED 402, 467; SOC W (SOC) 409; SOC W 471.

CHINESE (CHNS)

496. Independent Studies (1-18)
497. Special Topics (1-9)
499. Foreign Study — Advanced Chinese (3-12)

*CLASSICS (CLASS)

410. Classical Epic (3)
411. Classical Drama (3)
496. Independent Studies (1-18)
497. Special Topics (1-9)
499. Foreign Study — Classics (1-6)

500. Introduction to Classical Scholarship (1-6) Lectures on the methods and materials of classical scholarship. To be scheduled by graduate students in their first semester and as necessary thereafter.

504. Topography of Ancient Rome (3) Lectures and readings on physical development of the ancient city of Rome from earliest habitation to time of later empire.

597. Special Topics (1-9)

*The readings are in English; knowledge of Greek and Latin is not required.

COMPUTATIONAL FLUID DYNAMICS

Students interested in computational fluid dynamics may select the following courses, which are described under the majors of Aerospace Engineering and Mechanical Engineering: AERSP 423, AERSP (M E) 526, 527, 528, AERSP 529, and M E 540.

EARTH AND MINERAL SCIENCES (EM SC)

420. (SOC 420, S T S 420) Energy and Modern Society (3)

596. Individual Studies (1-9)

EAST ASIAN STUDIES (EA ST)

401. East Asian Studies (3-6)

ENGINEERING (ENGR)

495. Engineering Co-Op Work Experience III (1-3)

588. Seminar for Teaching Assistants in Engineering (1) A seminar course considering instructional issues and principles for engineering instruction and industrial training.

594. Master's Paper Research (1-3) Investigation of a specific engineering problem and development of a scholarly written report in partial fulfillment of requirements for a master's degree in engineering.

602. Supervised Experience in College Teaching (1-3 per semester, maximum of 6)

ENVIRONMENTAL RESOURCE MANAGEMENT (E R M)

405. Senior Seminar (1)
411. Legal Aspects of Resource Management (3)
412. Resource Systems Analysis (3)
413. Case Studies in Ecosystem Management (3)
421. Pollutant Impacts on Plants (1)
422. Pollutant Impacts on Animals (1)
423. Pollutant Impacts on Foods (1)
424. Pollutant Impacts on Aquatic Systems (1)
425. Economic Impacts of Environmental Pollution (1)
475. (C E 475) Water Quality Chemistry (3)
495. Internship (1-13)
496. Independent Studies (1-18)
497. Special Topics (1-9)

GERONTOLOGY

In a number of programs, students may select gerontology or adult development and aging as an area of specialization — in the behavioral and social sciences, in the biological sciences, and in certain professional programs. No major or degree in gerontology is offered. Information can be obtained from the Gerontology Center, S-210 Henderson Building South, 814-865-1717.

GREEK (GREEK)

401. Introductory Reading in Greek Literature (3)
420. Greek Prose Authors (3-6)
421. Greek Drama (3-6)
496. Independent Studies (1-18)
497. Special Topics (1-9)

509. Greek Seminar (3-9)

517. Greek Research (1-6) Prosecution of an assigned problem under the guidance of a member of the department.

HUMAN DEVELOPMENT (H DEV)

401. Professional Issues in Human Development (1-3)
410. Career Implementation in the Human Services (1)
494. Senior Thesis (1-10)
496. Independent Studies (1-18)
497. Special Topics (1-9)
499. Foreign Study — Human Development (1-6)

516. Methods of Research in Human Development (1-6) Review of problems and techniques of research in human development.

517. Multivariate Study of Change and Human Development (3) Models of development and change derived from empirical research utilizing multivariate research design and procedures. Prerequisites: at least three statistics courses, including correlation and regression analysis.

DOCTORAL MINOR IN THE HUMANITIES

Doctoral candidates may pursue an individualized program of study leading to a certificate minor or option (15-18 credits) in a broadly interdisciplinary area in the humanities. This program will normally provide teaching experience in an area of the humanities, and certification will be granted by the College of the Liberal Arts.

ITALIAN (IT)

415. Dante (3)
422. Italian Humanism and the Renaissance (3)
440. (FR 440, SPAN 440) Teaching of Romance Languages (3)
450. Nineteenth-Century Italian Literature (3)
460. Twentieth-Century Italian Literature (3)
490. Dante in Translation (3)
496. Independent Studies (1-18)
497. Special Topics (1-9)

588. Seminar in Italian Literature (3-12) Common and individual research in special problems.

596. Individual Studies (1-9)

597. Special Topics (1-9)

JAPANESE (JAPNS)

496. Independent Studies (1-18)
497. Special Topics (1-9)

LABOR AND INDUSTRIAL RELATIONS (L I R)

400. Comparative Industrial Relations Systems (3)
403. Labor-Management Relations (1)
404. Collective Bargaining Trends (3)
411. Industrial Relations Organizations (3)
414. Labor and Industrial Relations Theory (3)
433. The Law of Labor-Management Relations (3)
435. Labor Relations in the Public Sector (3)
437. Impasse Resolution in Labor Relations (3)

458. (HIST 458) History of American Organized Labor Since 1877 (3)
495. Labor Studies Internship (1-12)
496. Independent Studies (1-18)
497. Special Topics (1-9)

596. Individual Studies (1-9)

597. Special Topics (1-9)

LATIN (LATIN)

401. Introductory Reading in Latin Literature (3)
402. Latin Literature of the Republic (3-9)
403. Latin Literature of the Augustan Age (3-9)
404. Latin Literature of the Empire (3-9)
496. Independent Studies (1-18)
497. Special Topics (1-9)

500. Latin Literature (3-9) Readings in the major forms of Latin literature; content varies; course may be repeated.

510. Latin Seminar (3-6)

518. Latin Research (1-6) Prosecution of an assigned problem under the guidance of a member of the department.

LIBERAL ARTS (L A)

400. Changing Life-Styles (1)
401. Professional Development for the Liberal Arts Student (1)
460. Undergraduate Internship (1-6)
461. Academic Adviser Training (1)
481. (SPCOM 481) Computer Applications to Communication Studies (3)
482. Quantitative Methods for Humanists I (3)
483. Quantitative Methods for Humanists II (3)
484. (ENGL 484) Computational and Quantitative Stylistics (3)
495. Undergraduate Field Experience or Practicum (1-12)
496. Independent Studies (1-18)
497. Special Topics (1-9)
499. Foreign Study - Liberal Arts (1-9)

582. Approaches to Problem Solving for Humanists (3) A consideration of systematic individual and group approaches to problem solving and evaluation techniques. Prerequisite: introductory statistics.

596. Individual Studies (1-9)

597. Special Topics (1-9)

LIBRARY STUDIES (L ST)

+460. Introduction to Library Resources in the Biomedical Sciences (1)
470. Federal and Legal Information Resources (3)
480. Bibliographic Resources and Systems (3)
490. (HIST 490) Archival Management (1-3)
494. Research Projects (1-12)
496. Independent Studies (1-18)
497. Special Topics (1-9)

+ Offered only at The Milton S. Hershey Medical Center.

DOCTORAL MINOR IN LITERARY THEORY, CRITICISM, AND AESTHETICS

This is an interdisciplinary doctoral minor that is administered by two designated advisers, one from the Comparative Literature program and one from the Department of Philosophy. Students who are admitted to the minor will develop a course of study suited to their special interests. The minor for each student will be planned jointly by the student and the two advisers, in consultation with the student's doctoral adviser in his or her major field.

A minimum of 15 credits in addition to any required by the major will be chosen from among the following courses (6 credits [3 in comparative literature and 3 in philosophy] must be chosen from the asterisked courses; 9 credits in electives [of which 3 credits may be in individual studies] are to be selected from the remaining courses: ART H 410, C LIT 502*, 503*, 580, ENGL 581, FR 571, GER 591, PHIL 404, 413, 516*, 581*, 582, SPAN 587, SPCOM 503, 507, or THEA 503.

LITHUANIAN (LITH)

500. Structure of Lithuanian (3) Analysis of the phonology, morphology, and syntax of Lithuanian; comparative linguistic study of Balto-Slavic and Indo-European. Prerequisite: one graduate course in linguistics.

MATERIALS SCIENCE (MATSC)

401. Thermodynamics of Materials (3)
402. Materials Process Kinetics (3)
403. Microscopy of Materials (2)
404. Process Measurement and Control (1-3)
413. Solid-State Materials (3)
416. Materials Preparation (2)
430. Crystallography and Structural Characterization (3)
440. (E MCH 440) Nondestructive Evaluation of Flaws (3)
496. Independent Studies (1-18)
497. Special Topics (1-9)

501. Thermodynamics of Materials (3) Application of thermodynamics to materials equilibria and processes, including solution theory, electrochemical processes, capillarity, and the effect of stresses. Prerequisite: CHEM 451.

503. (G M 503) Kinetics of Materials Processes (3) Introduction to application of transition state theory and mass transfer to the kinetics of materials and mineral processes. Prerequisites: MATH 250, CHEM 451; MATSC 501 or G M 521.

511. (GEOSC 511) Instrumental Techniques Applied to Materials and Mineral Sciences Problems (1-7) See units A through G for description.

Unit A. (GEOSC 511A) Powder X-Ray Diffraction (1) Compound identification, lattice parameter measurement, and other applications of the powder diffraction method.
Unit B. (GEOSC 511B) Transmission Electron Microscopy (1) Principles and practice of transmission electron microscope operation. Students undertake individual projects.
Unit C. (GEOSC 511C) Spectroscopy (1) Emission spectrographic analysis of powders and atomic absorption analysis of solutions.
Unit D. (GEOSC 511D) Electron Microprobe Analysis (1) Qualitative and quantitative elemental analysis of microvolumes within solids. Emphasis on individual student project.
Unit E. (GEOSC 511E) Scanning Electron Microscopy (1) Principles and practice of scanning electron microscope operation. Students undertake individual projects.
Unit F. (GEOSC 511F) Absorption Spectroscopy (1) Techniques and instrumentation for UV-visible-near-infrared absorption and reflection, IR and far IR absorption, and Raman scattering spectroscopy.
Unit G. (GEOSC 511G) Analytical Electron Microscopy (1) Modern analytical electron microscope techniques: scanning transmission electron microscopy; electron energy loss spectroscopy; energy dispersive analysis of X-rays. Prerequisite: MATSC (GEOSC) 511B.

512. (G M 512) Principles of Crystal Chemistry (3) Relation of structure to ionic size and nature; influence of pressure and temperature on structure; chemical-structural defects, crystalline solutions, phase-transitions.

514. Characterization of Materials (3) Classical and new (microprobe, scanning microscope, magnetic resonance, and Mossbauer) techniques for the characterization of composition, structure, defects, and surfaces.

524. (G M 524) Vibrational Spectra of Materials and Minerals (3) Infrared and Raman spectroscopy of materials, with applications to mineralogy, geochemistry, ceramics, and glass research.

530. X-Ray Crystallography and Diffraction (3) Reciprocal lattices and the Ewald sphere construction; crystal structure determination by powder and single crystal techniques; space groups. Prerequisite: MATSC 430.

531. Transmission Electron Microscopy (3) Diffraction pattern analysis and simple contrast theory applied to the structures of materials; analytical techniques in the microscope. Prerequisite: MATSC (GEOSC) 411B.

535. (G M 535) Geometrical Crystallography (3) Derivation of lattices, types, point groups, and space groups; and group theory applied to crystallography and spectroscopy.

536. Techniques for Surface Analysis (3) Electron spectroscopy, low-energy ion-beam techniques, high-energy ion-beam techniques, low-energy electron diffraction, and ellipsometry. Prerequisite: PHYS 203 or 204.

538. Electron Beam Analysis of Solids via X-ray and Electron Emission (3) Theory of phenomena occurring in electron-bombarded solids and their applications to analysis of solids.

540. Crystal Anisotropy (3) Symmetry aspects of crystals and physical properties. Matrix and tensor methods. Prerequisite: PHYS 412.

542. Magnetic Methods in Materials Science (3) Static magnetic (susceptibility type) and spectroscopic methods (nuclear and electron magnetic resonance, Mossbauer spectroscopy) for materials characterization and structural analysis. Prerequisite: PHYS 413.

554. Electronic Spectra of Materials (3) Crystallographic and thermodynamic applications of crystal field theory. Electronic spectra of crystals and glasses. Luminescent spectra and phosphor characterization. Prerequisite: PHYS 471.

570. Catalytic Materials (3) Preparation and characterization of solid catalytic materials. Relationships between their surface, defect, and electronic properties and catalytic activity. Prerequisite: CHEM 452.

590. Colloquium (1-3)

596. Individual Studies (1-9)

597. Special Topics (1-9)

MINERAL ENGINEERING (MIN E)

414. Planning and Control for the Mineral Industries (3)
415. Management in the Mineral Industries for Environmental, Legal, and Health and Safety Problems (3)
416. Design of Training Programs for the Mineral Industries (3)
417. Computer-Aided Analysis of Mining Systems (3)
496. Independent Studies (1-18)
497. Special Topics (1-9)

PATHOLOGY (PATH)

501. Principles of Pathology (4) The fundamentals of reaction to injury at cellular and tissue levels emphasizing the pathogenesis of functional, structural, and biochemical abnormalities.

520. Biology of Neoplasia (3) Detailed examination of the initiation and pathogenesis of animal neoplasms with emphasis on the relationship to human neoplasia. Prerequisite: admission to College of Medicine.

522. Cancer Immunology and Immunotherapy (2) Detailed study of recent advances in host response to malignancy in man and experimental animals. Prerequisite: PATH 501 or MICRO 554.

597. Special Topics (1-9)

PEDIATRICS (PED)

525. Clinical Genetics (5-10) Mendelian and molecular principles of human genetics; genetic bases of human disease, quantitative human genetics, prenatal diagnosis, genetic counseling.

526. Human Cytogenetics (2) Human chromosome identification; structure, replication, and evolution of human and other eukaryotic chromosomes in cytogenetic and molecular terms.

PLANT SCIENCE (PLTSC)

400. Principles of Plant Science Research (2)
496. Independent Studies (1-18)
497. Special Topics (1-9)

PORTUGUESE (PORT)

405. Advanced Composition and Conversation (3)
456. Brazilian Literature in English Translation (3)
496. Independent Studies (1-18)
497. Special Topics (1-9)

588. Seminar in Portuguese and Brazilian Literature (3-12) Common and individual research in special problems.

596. Individual Studies (1-9)

597. Special Topics (1-9)

PROFESSIONAL SKILLS MINOR

This minor seeks to broaden the analytic, informational, and communications skills that are required by all Ph.D. programs. Doctoral candidates in any disciplinary major at the University may enroll. The program requires the completion of the following course work.

Total credits required: 15.

L A 582. Approaches to Problem Solving for Humanists (3)

L A 596. Individual Studies (3)

L ST 480. Bibliographic Resources and Systems (3)

ENGL 418. Advanced Technical Writing and Editing (3)

or ENGL 417. The Editorial Process (3)

SPCOM 552. Oral Communication in Industry, Business, and Government (3)

RELIGIOUS STUDIES (RL ST)

400. Theories of Religion (3)
401. Studies in Comparative Religion (3)
402. Contemporary Religious Thought (3)
408. Hindu Studies (3)
409. Buddhist Studies (3)
411. Jewish Studies (3)
420. Major Christian Thinkers (3)
422. Religion and American Culture (3 per semester, maximum of 6)
430. Religious Ethics (3)
479. (PSY 479) Religion and Culture in Freudian Thought (3)
496. Independent Studies (1-18)
497. Special Topics (1-9)

502. Studies in Comparative Religions (3-6) Cross-cultural comparative studies of two or more world religions.

521. Issues in Western Religion (3-6) Seminar. Study of selected issues in Western religion.

522. Advanced Studies in American Religion (3-6) In-depth inquiry into either a period, a movement, or a topic of American religion.

530. Religion and Society (3-6) Studies of mutual influences and effects of religion and secular phenomena.

532. Religion and Social Problems (3-6) Study of a selected social issue, or constellation of issues, with analysis of its religious and normative dimensions.

536. Religious Structures and Processes (3-6) Study of the relationship between religion as social structure and as a dynamic social function.

539. Advanced Studies in Religious Ethics (3-6) A systematic study of the structure and essential themes of ethics of religious institutions and thinkers.

590. Colloquium (1-3)

596. Individual Studies (1-9)

597. Special Topics (1-9)

RUSSIAN (RUS)

401. Advanced Listening Comprehension in Russian (3)
426. Dostoevsky (3)
427. Tolstoy (3)
430. Methods and Materials for Teaching Russian (3)
450. History of the Russian Language (3)
460. Linguistic Analysis of Contemporary Russian (3)
496. Independent Studies (1-18)
497. Special Topics (1-9)

*001G. Technical Russian for Graduate Students (3) Prepares student to translate technical and scientific texts. No previous knowledge of Russian is required.

*002G. Russian Texts (3) Development of skill in translating Russian texts in the sciences and social sciences. Prerequisite: RUS 005 or 001G.

501. Readings in Russian Literature (3-6) Prerequisite: RUS 204.

525. Pushkin (3) Pushkin's significance in Russian literature; his relation to other European literatures; *Eugene Onegin* and selected shorter works.

540. Eighteenth-Century Russian Literature (3) Study of the major writers and literary developments in this period of the secularization and modernization of Russian literature.

542. Seminar in Soviet Literature (3-6) Works of representative Soviet writers; individual research in contemporary Soviet literature and literary criticism.

570. Old Russian Literature (3) Analysis of Russian literary monuments in the original, 1100-1700. Prerequisite: SLAV 550.

602. Supervised Experience in College Teaching (1-3 per semester, maximum of 6)

SCIENCE (SC)

400. Consequences of Science (1)

*No graduate credit is given for this course.

SCIENCE, TECHNOLOGY, AND SOCIETY (S T S)

420. (EM SC 420, SOC 420) Energy and Modern Society (3)
430. (NUTR 430) Global Food Strategies: Problems and Prospects for Reducing World Hunger (3)
432. (PHIL 432) Medical Ethics (3)
435. (PHIL 435) The Interrelation of Science, Philosophy, and Religion (3)
450. Nuclear Arms Issues (2-3)
460. (PL SC 460) Science and Public Policy (3)
471. Radiation, Reactors, and Society (3)
489. (PHIL 489) Technology and Human Values (3)
496. Independent Studies (1-18)
497. Special Topics (1-9)
500. Integrating Science and Technology into Society (3) Interdisciplinary analysis of critical issues for science, technology, and society. Prerequisite: graduate standing at Penn State.
590. Colloquium (1-3) Prerequisite: graduate standing at Penn State.
594. Research Topics (1-18)
597. Special Topics (1-9)

Note: *This program is designed to examine critically the impact of scientific investigation and technological development on society and the influence of human needs on scientific investigation and technological development.*

SLAVIC (SLAV)

500. Bibliography and Research Techniques (3) Tools and methods of research, designed for students preparing to do independent investigation of problems in Slavic languages and literatures.

510. Structure of the South Slavic and West Slavic Languages (3-12; 3 credits per language) Linguistic analysis of a particular South Slavic (Bulgarian, Macedonian, Serbo-Croatian, Slovenian) or West Slavic (Czech, Lusatian, Polish, Slovak) language. Prerequisite: RUS 460 or one graduate course in linguistics.

550. Old Church Slavic (3) Reading and study of that corpus of religious and liturgical documents representing the first written records of a Slavic tongue.

SOCIAL WORK (SOC W)

401. Social Work Methods: Individuals, Families, and Small Groups (4)
409. (SOC 409) Racial and Ethnic Inequality in America (3)
411. Social Work Methods: Organizations and Communities (4)
450. Public Welfare Policy and Services (3)
471. Rural Social Work (3)
496. Independent Studies (1-18)
497. Special Topics (1-9)

URBAN AND REGIONAL PLANNING (UR PL)

400. Principles of Regional Planning (3)
401. Planning Law and Its Application (3)
410. Planning Programs (3)
440. Problems in Community and Regional Planning (1-9)
441. Introduction to Computer Applications (3)
442. Data Analysis and Computer Graphics (3)

500. (P ADM 503) Research Methods (1-3) Examination of research methodologies relevant to administration, planning, and public policy. Prerequisite: 3 credits in statistics.

501. Applied Methodologies in Regional Planning (3) Selected methodologies used in planning, including demographic projections, simulations, network analyses, threshold analyses, allocation and location models.

502. Regional Systems Analysis (3) Developmental planning, its characteristics and consideration in a cross-cultural context, including study of selected approaches and analysis critiques.

510. Planning Techniques and Analysis: Socio-Economic (3) Socio-economic considerations in planning, including data collection and analysis for planning purposes.

520. Planning Techniques and Analysis: Environmental (3) Application of selected concepts and methodologies in environmental planning.

530. Planning Techniques and Analysis: Physical (3) The physical city and its shaping by political, economic, social, and cultural conditions.

540. Problems in Regional Planning (3) Planning problems in selected subject areas.

542. Housing for Urban Planners (3) An introduction to housing and housing issues in an urban environment.

543. Community Energy Planning (3) Appraisal methods for community planning, development, and management, consistent with dramatically rising energy costs.

544. Rural Development Planning (3) Planning and implementing practical approaches to rural development.

545. Planning in Developing Countries (3) Approaches to planning and implementing urban and regional development in lesser developed countries.

546. Land Use Planning and Management (3) Land use planning and management: theory and practice.

547. Environmental Planning (3) Analytical skills in environmental planning.

587. Master's Project (1-6) An original scholarly master's project initiated by the student, supervised by an appropriate professor, and judged by a committee.

590. Colloquium (1-3)

595. Planning Internship (1-6) Internship with a planning agency, under supervision of a graduate faculty member. Prerequisite: approval of program chairman.

596. Individual Studies (1-9)

597. Special Topics (1-9)

WOMEN'S STUDIES (WMNST)

Students who want to take courses in women's studies may select from the following: C LIT 406, EDTHP 412, ENGL 490, EXSCI 424, PSY 471, SOC 430, or SPCOM 455.

496. Independent Studies (1-18)

497. Special Topics (1-9)

596. Individual Studies (1-9)

OTHER MEMBERS OF THE GRADUATE FACULTY

Senior Members of the Graduate Faculty
Paul M. Harrison, Ph.D. (Yale) *Professor of Religious Studies*
Joseph Paternost, Ph.D. (Indiana) *Professor of Slavic Languages*
Charles S. Prebish, Ph.D. (Wisconsin) *Associate Professor of Religious Studies*
William R. Schmalstieg, Ph.D. (Pennsylvania) *Professor of Slavic Languages.*
Judith Van Herik, Ph.D. (Chicago) *Associate Professor of Religious Studies*

Associate Members of the Graduate Faculty
Archibald Allen, Ph.D. (Queen's-Belfast) *Associate Professor of Classics*
Ronald L. Filippelli, Ph.D. (Penn State) *Professor of Labor Studies*
James J. Gebhard, Ph.D. (Indiana) *Assistant Professor of Russian*
Gerald P. Glyde, Ph.D. (Illinois) *Associate Professor of Labor Studies*
Peter Gottlieb, Ph.D. (Pittsburgh) *Associate Librarian, Historical Collections and Labor Archives; Assistant Professor of Labor Studies*
Raymond L. Hogler, Ph.D. (Colorado) *Assistant Professor of Labor Studies*
Thomas J. Juravich, Ph.D. (Massachusetts) *Assistant Professor of Labor Studies*
Ernest B. Lowrie, Ph.D. (Yale) *Associate Professor of Religious Studies and American Studies*
Bruce M. Stephens, Ph.D. (Drew) *Associate Professor of Humanities and Religious Studies*
E. A. Vastyan, B.D. (Episcopal Theological, Cambridge) *Professor of Humanities and Religious Studies*

FACULTY INDEX

Abdallah, S. A. 66
Abler, R. F. 230
Abou-Kassem, J. H. 330
Abrahms, M. D. 175, 219, 346
Abrams, S. M. 85, 323
Abruzzi, W. S. 87, 175
Abt, V. 378
Achterberg, C. 323
Ackerman, C. L. 60
Adair, J. H. 133, 382
Adams, R. S. 85
Adams, W. S. 103, 154, 187
Adewumi, M. A. 304, 330
Ahmed, S. 176
Airhihenbuwa, C. O. 246
Akritas, M. G. 392
Albert, E. K. 308
Albinski, H. S. 350
Albrecht, B. A. 295
Albright, G. H. 90
Alessandro, J. V. 185
Alexander, D. K. 396, 403
Alexander, S. S. 233, 241
Allara, D. 137, 353
Allcock, H. R. 137
Allen, A. 420
Allen, D. N. 348
Allen, S. J. 122
Allison, W. H. 399
Alter, T. R. 70
Amateau, M. F. 192, 195
Amburgy, P. 95
Amenta, M. 321
Ameringer, C. D. 252
Ammon, R. I. 396
Anderson, A. A. 94
Anderson, A., Jr. 91
Anderson, D. A. 140
Anderson, J. B. 137
Anderson, J. H. 282
Anderson, P. M. 74, 77
Andrews, G. E. 282
Anthony, A. 106, 340
Antle, C. E. 326, 392
Aplan, F. F. 207, 304, 305
Ariew, R. 223
Armentrout, S. 282
Armstrong, D. 313
Arnold, D. E. 174, 215, 219
Arnold, J. B. 199
Arnold, S. F. 392
Aron, G. 140, 206, 207
Aronson, N. N., Jr. 101, 311
Arteca, R. N. 257, 346
Asbell, B. 199
Ashok, S. 187, 192, 195, 381
Askov, E. N. 64, 164, 172, 398
Aspaturian, V. V. 350
Astley, W. G. 111
Atwater, D. F. 388
Austin, L. G. 226, 305, 326
Austin, R. L. 377
Axt, P. 282
Aydin, K. 188
Ayers, J. E. 227, 343
Babu, G. J. 392
Badzian, A. R. 382
Bagby, J. W. 111
Baggett, C. D. 72, 407
Baghdoyan, H. A. 317
Baile, C. A. 85
Baker, D. E. 78, 174, 207
Baker, P. T. 87
Baker, S. B. 161
Balaban, C. D. 83, 317
Balaban, J. 199
Balaban, J. A. 151
Balch, W. R. 357
Baldi, P. H. 273, 398
Baldwin, R. C. 219, 346
Bandini, P. L. 91
Bannon, P. R. 295
Banyaga, A. 282
Baratta, A. J. 319, 381
Barbato, G. F. 228, 356
Barlow, J. 156
Barnard, M. 151, 383
Barner, P. A. 72
Barnes, H. L. 233, 236
Barnes, S. M. 396, 403
Barron, E. J. 233, 239
Barsch, G. R. 337, 381
Bartlett, G. L. 300
Bartlett, W. P. 83
Barton, M. L. 81, 263, 362
Barton, P. 135, 207
Barton, R. L. 278
Battaglia, A. M. 271
Baumrucker, C. R. 85, 323, 340
Bayard, S. P. 151
Bayless, J. R. 399
Bealer, R. C. 374
Beard, J. L. 323
Beckerman, S. J. 87, 174, 398
Beebe, J. H. 60
Beebee, T. O. 151, 243
Beegle, D. B. 78
Beelman, R. B. 217
Begnal, M. H. 151, 199
Beierlein, J. G. 69, 326
Beittel, K. R. 94
Belegundu, A. D. 289
Bell, P. E. 164
Bellis, E. D. 106, 174
Belsky, J. 260
Benesi, A. J. 137
Benkovic, S. J. 137
Bennett, P. D. 111
Benson, T. W. 388
Bentley, J. M. 368
Berg, C. C. 78, 228
Berlin, C. M. 227, 332
Berman, P. 156
Bernard, T. J. 62, 148
Berner, R. T. 278
Bernheim, R. A. 137
Bernlohr, R. W. 101
Best, J. H. 185
Beyer, K. H., Jr. 332
Bhagat, R. 192, 196
Bhalla, A. S. 382
Bhavanandan, V. P. 105, 131
Bieniawski, Z. T. 304, 308
Bierman, K. L. 357
Biggers, J. V. 381
Billet, M. L. 66
Billingsley, M. L. 131, 317, 332
Birbaumer, N. 357
Bise, C. J. 304, 308
Bissinger, B. H. 197, 208
Bither, S. W. 111
Bitler, W. R. 292
Bixler, E. O. 317
Blackadar, A. K. 173, 295
Blair, D. 323
Blankenhorn, P. R. 219
Blatt, R. G. 197
Block, A. A. 62
Blood, G. W. 144
Blood, I. M. 144
Bloom, J. R. 343
Blumberg, M. 126
Blume, G. W. 164
Bode, W. M. 204
Bohren, C. F. 295
Bollag, J. 78, 174, 207
Bollinger, R. A. 197
Bona, J. L. 282
Bond, E. W. 176
Bond, R. S. 219
Bord, R. J. 377
Borklund, E. W. 199
Borkovec, T. D. 357
Bose, N. K. 187
Boswell, M. T. 392
Bosworth, S. C. 78
Bowers, T. G. 362
Bowersox, T. W. 219
Bowman, T. A. 270
Boyd, W. L. 179, 348
Boyer, C. D. 227, 257, 346
Boyle, J. S. 343
Bradley, W. R. 94
Bragger, J. D. 223, 398
Brand, E. 362
Brannon, D. 249
Brantley, S. L. 233, 236, 239
Brass, D. J. 111
Brault, G. J. 222
Brawley, E. A. 348, 378
Bredeson, P. V. 179
Bresler, R. J. 368
Bressoud, D. M. 282

Bronner, S. J. 81, 263
Bronzini, M. S. 140, 326
Brooks, R. P. 175, 215, 219
Brown, D. J. 357
Brown, F. M. 357
Brown, I. V. 252
Brown, J. L. 323
Brown, J. L., Jr. 60, 187
Brown, P. W. 133
Brown, R. J. 126, 208
Brown, T. A. 126
Brownawell, W. D. 282
Browning, B. W. 243, 398
Bryan, R. M., Jr. 317
Bryant, D. 227, 298, 311, 346
Bryon, R. M. 341
Buck, J. D. C. 199
Buckalew, R. E. 273
Buffington, D. E. 74, 77
Bui, T. 156
Bullington, B. 62, 148
Burkholder, R. E. 199
Burns, L. C. 199
Burroughs, C. B. 60, 192, 196
Buskirk, E. R. 103, 207, 209, 323, 340
Buss, E. G. 227
Butt, D. E. 388
Byers, R. A. 204
Cady, P. D. 140
Cahill, A. G. 348, 365
Cahir, J. J. 173, 295
Caldwell, W. E. 179
Calvin, D. D. 204
Camarata, S. M. 144
Camci, C. 66
Cameron, E. A. 174, 204
Campbell, J. L. 388
Campbell, T. L. 112
Cantrell, J. M. 72, 174, 204
Carline, R. F. 174, 215, 219
Carlson, A. 135
Carlson, R. A. 357
Carlson, T. N. 295
Carpenter, L. A. 187
Carr, M. A. 313
Carroll, J. G. 149, 249
Carroll, J. L. 111
Carson, J. M. 74, 77
Cartwright, C. A. 164, 386
Cartwright, G. P. 386
Cash, E. H. 85
Casida, L. E. 174, 298
Castleman, A. W. 137
Catchen, G. L. 319
Cavalier, T. 266, 326
Cavanagh, P. R. 209
Cavinato, J. L. 111
Chan, M. H. W. 337
Chan, P. 93
Chander, S. 305
Chandra, M. J. 266, 304, 326
Chang, P. H. 350
Charleston, G. M. 197, 327
Charney, D. H. 199, 273
Chatterjee, K. 111, 326
Cheatham, H. E. 161
Chen, C. 188
Chen, G. 282, 326
Cheney, P. G. 151, 199
Cheung, F. 288
Chisholm, R. F. 208, 368
Cho, K. 112
Chowla, P. 282
Christ, B. J. 344
Christiansen, M. L. 371, 373
Christina, R. W. 209, 340
Christy, D. P. 111, 326
Churchill, E. F. 81, 263
Cimbala, J. M. 289, 350
Ciolkosz, E. J. 78
Clark, A. G. 107, 175, 228
Clark, H. T. 182
Clark, J. H. E. 173, 295
Clausen, C. 199
Clement, P. F. 253
Clemente, F. 377
Cleveland, R. W. 78, 227
Clingempeel, W. G. 362
Clogg, C. C. 170, 377, 392
Cochran, P. L. 111
Cohen, H. 388
Cohen, P. H. 266
Cohn, S. 91, 149, 276
Cole, C. A. 197, 208
Cole, H., Jr. 343
Cole, M. W. 337
Cole, R. H. 213
Coleman, M. M. 353
Collison, C. H. 204
Colman, R. W. 362
Colony, P. C. 83
Connor, J. D. 316, 332
Connor, J. R. 83, 317
Considine, T. J. 302, 348
Conway, J. C. 192, 195
Cook, D. N. 399
Cook, J. A. 93
Cookson, P. S. 64
Coraor, L. D. 154, 187
Corbett, E. S. 219
Cornwell, P. R. 357
Corrington, R. 334
Cosgrove, D. 106, 110, 346
Coulson, N. E. 176
Cowen, B. S. 405
Coyle, J. J. 111
Craig, R. 227, 257
Crane, R. G. 230
Crawford, C. O. 374
Crider, D. M. 374
Crnic, K. A. 357
Crocken, W. E. 399
Crocker, K. J. 176
Crockett, E. J. 260
Croskey, C. 188
Cross, G. S. 253
Cross, L. E. 187, 381
Croushore, D. D. 176
Crouter, A. C. 260
Crum, R. P. 112
Cuddy, L. 293
Cuffey, R. J. 173, 174, 233, 239
Culpan, R. 126
Cummings, D. 188
Cunningham, R. L. 78, 207
Curley, A. J. 111
Curtis, J. 350
Curtis, S. M. 72, 348, 407
Cushing, B. E. 111
Cutler, A. 96
Cutler, P. H. 337
Dahir, S. H. M. 197
Dalbor, J. B. 273, 383
Danahy, M. C. 223
Daniels, R. R. 346
Danneman, P. J. 270
Danner, R. P. 135
Das, C. 188
Das, M. B. 154, 187, 381
Dattilo, J. P. 371, 373
Daubert, T. E. 135
Daum, D. R. 74, 77
Davidson, E. A. 105, 131, 227
Davinroy, T. B. 141
Davis, A. 233, 239
Davis, D. D. 174, 343
Davis, J. W. 266
Davis, S. G. 111, 327
Daws, B. W. 72
Dean, J. W. 112
Deaver, D. R. 85, 341
DeBarber, J. P. 188
Deering, R. A. 227, 311
Deihl, N. C. 313
Deines, P. 233, 236
DeJong, G. F. 170, 377
Delansky, J. F. 188
DeMicco, F. J. 276
Dempsey, B. A. 207
de Pena, R. G. 173, 295
Derbyshire, F. J. 226
De Rooy, J. 126
Detwiler, W. L., Sr. 408
Deutsch, F. R. 282
Deutsch, S. 66, 141
Devine, T. J. 176
DeWalle, D. R. 174, 207, 219
Dexter, C. R. 126
Diamond, J. E. 72
Diethorn, W. S. 319
Dimick, P. S. 217
Dirsmith, M. W. 111

Di Vesta, F. J. 182, 357, 376, 398
Divine, H. A. 149, 276
Donaldson, J. F. 64
DonTigny, D. R. 93
Doores, S. 217
Dordevic, M. 263
Downs, R. C. S. 199
Downs, R. M. 230
Draguns, J. G. 357, 398
Duda, J. L. 135
Duich, J. M. 78
Duiker, W. J. III 252
Duke, W. L. 233, 239
Dulaney, W. L. 278
Dulikravich, G. S. 66
Duncan, R. L. 197
Dunham, R. E. 388
Dunkel, P. A. 273, 388
Dunn, D. R. 371, 373
Dunn, J. 260
Dunn, J. W. 69, 327
Dunson, W. A. 106, 174
Dupuis, M. M. 164, 172
Dupuis, V. L. 164
Durbin, N. E. 378
Dutton, J. A. 173, 295
Dworkin, B. R. 317
Dwyer, F. M., Jr. 164
Ebbinghaus, E. A. 151, 243, 273
Eberhart, R. J. 340, 405
Eckhardt, C. D. 151, 199
Eckhardt, R. B. 87, 227
Egbelu, P. J. 266
Eggebeen, D. J. 260
Eggert, G. G. 252
Eggler, D. H. 233, 236
Eisele, F. R. 148, 248
Eisenstein, J. 350
Elliott, E. S. 149
Elliott, G. C. 346
Elliott, H. A. 74, 77, 208
Elmagarmid, A. 154, 188
Elsworth, D. 308
Engel, A. J. 135, 207
Engelder, T. 233, 239
Engle, C. C. 85
Enis, C. R. 112
Enscore, E. E., Jr. 266, 327
Enteen, G. M. 252
Epp, D. J. 69
Erickson, R. 111, 230, 327
Ertekin, T. 304, 327, 330
Estes, D. 260
Etherton, T. D. 85, 323, 340
Etzweiler, G. A. 187
Evans, D. E. 72, 407
Evensen, K. B. 257, 346
Everett, P. B. 111, 148, 276
Ewing, A. G. 137
Ezard, L. A. 197
Ezzell, J. R. 111
Faeth, G. M. 288
Fairall, C. W. 295
Fairchild, F. E. 164, 170
Fairweather, J. E. 250, 348
Fairweather, S. E. 219, 327
Fales, S. L. 78, 346
Farr, J. L. 357
Farrell, P. 371, 373
Farrell, P. A. 209, 340
Faulkner, J. E. 377
Feigelson, E. D. 98
Feldman, J. M. 313
Feldman, K. S. 137
Feldman, L. 313
Feller, I. 176, 348
Fender, J. 176
Feng, T. 154, 187
Fennell, M. L. 377
Fenner, B. L. 313
Ferguson, F. 208, 263
Ferguson, F. G. 207, 227, 405
Ferrara, W. L. 111, 304
Ferraro, A. J. 187
Feuchtwang, T. E. 337
Filippelli, R. L. 420
Findeis, J. F. 70, 327
Firmin, C. H. 399
Fisher, F. E. 149
Fitz, E. E. 151, 383
Fitzgerald, R. P. 199
Fizel, J. L. 122
Flannery, D. D. 403
Flay, J. C. 334
Fleischer, R. 96
Fleming, G. N. 337
Flipse, R. J. 85
Flyer, D. C. 300
Foderaro, A. H. 319
Fonash, S. J. 103, 187, 192, 195, 381
Forbes, G. S. 295
Formanek, E. 282
Forsythe, R. H. 217
Fortney, V. 209
Fosmire, G. J. 323
Foti, V. M. 334
Fox, R. H. 78, 174
Frangos, J. A. 135
Frank, J. A. 344
Frank, T. A. 144
Frank, W. M. 295
Frankl, D. R. 337
Frantz, J. B. 252
Frantz, R. L. 304, 308
Fraser, A. B. 295
Frautschi, R. L. 222
Freed, N. 337
Freeman, W. E. 62, 148
Freivalds, A. 103, 266
French, J. L. 182, 376, 386
Frenklach, M. Y. 226
Friedman, R. S. 348, 350
Frisque, R. J. 295, 311
Fritsch, J. M. 295
Fritton, D. D. 78
Fritz, P. J. 227, 346
Froke, M. D. 278
Funk, R. L. 137
Furer, M. 156
Furlong, K. P. 233, 236, 239, 241
Gaffney, E. V. 298, 340
Gajar, A. H. 386
Gallagher, G. W. 253
Gallagher, J. D. 209
Gallaher, A. J. 144
Gallup, D. A. 164
Games, P. A. 182, 260
Gamm, L. 148, 248, 348
Gannon, R. H. 199
Gardner, T. W. 233, 239
Garmire, G. P. 98
Garner, R. L. 253
Garrison, B. J. 137
Garven, J. R. 112
Gaumond, R. P. 103, 340
Gburek, W. J. 141
Gebhard, J. J. 420
Geder, L. 300
Geiger, R. L. 251
Gelman, S. R. 378, 348
Gentzler, I. M. 362
Geoffroy, G. L. 137
Georges-Abeyie, D. E. 62, 148
Gerardin, P. 282
Gerhold, H. D. 219, 227
Geroy, G. D. 407, 408
Geschwindner, L. F. 89
Geselowitz, D. B. 103, 187
Ghosh, M. M. 140, 206, 207
Ghosh, N. 282
Gibson, A. A. 399
Gibson, R. L. 93
Gidez, R. E. 199
Gilberg, T. 350
Gilbert, H. R. 144
Gildenblatt, G. S. 187
Gildow, F. E. 344
Gillis, W. 70
Gilmore, B. J. 289
Gilmore, J. W. 353
Gindes, M. 357
Ginsberg, R. E. 151, 334
Ginzburg, L. D. 253
Gioia, D. A. 111
Gitelson, R. J. 371, 373
Gittings, G. I. 112
Given, P. H. 226, 304
Glasner, M. 282
Glass, E. D., Jr. 217
Glyde, G. P. 420

Godbey, G. C. 371, 373
Golany, G. 91
Gold, D. P. 233, 239
Gold, L. P. 137
Goldberg, J. H. 266
Goldman, J. N. 300
Goldschmidt, A. E., Jr. 253
Goldstine, J. 156
Good, R. H., Jr. 337
Goode, F. M. 70
Goodman, L. 386
Goodman, S. R. 131, 316, 340
Goodstein, L. I. 62, 148
Goodwin, K. 228
Gordon, B. III 353
Gordon, R. L. 207, 302, 327
Gorlow, L. 358, 376
Gotolski, W. H. 140
Gottlieb, K. A. 228
Gottlieb, P. 421
Gould, P. R. 230, 327
Gouran, D. S. 388
Grader, A. S. 330
Graefe, A. R. 371, 373
Graetzer, R. 337
Graham, E. K. 233, 241, 381
Graham, R. J. 81, 263
Graham, T. R. 81, 263
Graves, K. R. 93
Graves, R. E. 74, 77
Gray, B. 111
Gray, K. C. 407, 408
Grecco, S. R. 151, 199
Green, D. J. 133
Green, M. H. 323, 340
Greene, F. E. 332
Greene, G. 323
Greenfield, R. J. 233, 241
Greenlaw, P. S. 111
Gregg, C. M. 341, 356
Gregg, R. B. 388
Grenier, G. H. 197
Griel, L. C. 405
Griffin, R. M., Jr. 276
Griffith, C. E. 253
Griffith, J. W. 270
Griffiths, T. J. 209
Grimes, D. M. 187
Grimes, J. 321
Grosholz, E. R. 334
Grossman, K. M. 151, 223
Grotch, H. 337
Grun, P. 106, 110, 228, 257
Grutzeck, M. W. 382
Guadagnolo, F. B. 371, 373
Guber, A. L. 174, 233, 239
Guerney, L. F. 376
Gunaydin, M. 337
Gupta, S. 156
Gustine, D. L. 78, 346
Guthrie, G. M. 357
Guthrie, H. A. 323
Haas, C. G., Jr. 137
Haeseler, C. W. 257
Hagberg, G. 263
Hagen, D. R. 85, 340
Hager, H. 96
Hager, W. 282, 327
Hahn, H. T. 192, 195
Hahn, K. T. 282
Haight, F. A. 392
Hale, L. C. 187
Hale, R. L. 182, 376
Hale, T. 398
Hale, T. A. 151, 222
Hall, J. K. 78
Hallberg, M. C. 69, 327
Halsey, M. T. 383
Halverson, H. G. 219
Ham, I. 266
Hamilton, G. A. 137
Hamilton, R. H. 103, 110, 346
Hammerstedt, R. H. 101
Hammond, J. D. 111
Hand, I. 208, 368
Hannafin, M. J. 164
Hanson, W. P. 93
Hardison, R. C. 101, 228, 311, 346
Hardy, H. R., Jr. 308
Hargrove, G. L. 85, 228
Harkavy, R. E. 350
Harkness, W. L. 327, 392
Haronosky, C. M. 266
Harpending, H. C. 87, 170
Harpster, H. W. 85, 323
Harrington, J. D. 78
Harris, D. V. 209
Harris, W. V. 199
Harrison, I. R. 353
Harrison, P. M. 420
Harrison, T. P. 111, 327
Harrison, T. S. 316, 340
Hartman, W. T. 179, 327
Hartwig, N. L. 78
Hartzler, J. S. 197
Harvey, I. E. 334
Harvey, P. B., Jr. 252
Harwood, J. T. 199
Hass, L. F. 105
Hassler, W. W., Jr. 252
Hatch, C. 72
Hatch, J. W. 87
Hatley, O. E. 78, 213
Hauser, G. A. 388
Hausman, C. R. 334
Hawkins, R. A. 317, 340
Hayek, S. I. 60, 192, 195
Hayya, J. C. 111, 327
Heald, C. W. 85
Heasley, D. K. 213, 374
Heian, J. B. 112
Heicklen, J. P. 137
Heid, M. K. 164
Heinrich, A. J. 85, 323
Heinsohn, A. L. 72, 213
Heinsohn, R. J. 206, 207, 288
Heisler, G. M. 219
Heitmann, G. J. 111, 327
Helfferich, F. G. 135, 207
Hellman, J. R. 133
Henderson, R. E. 288
Hendrickson, R. M. 250
Hendrickson, W. G. 131, 228, 300
Henisch, H. K. 96, 337
Henk, W. A. 396, 403
Henry, J. J. 288
Henson, W. L. 70
Henszey, B. N. 111
Herendeen, J. B. 176
Herman, R. H. 282, 337
Hermanowicz, H. J. 164
Herr, E. L. 161
Herrmann, R. O. 69
Hershberger, T. V. 85, 323
Hersey, R. M. 332
Hessel, M. 93
Hettche, L. R. 60, 192, 195
Hettmansperger, T. P. 392
Hetzel, R. D. 278
Heuser, C. W. 257, 346
Hibbard, E. 106
Hibbard, L. S. 317
Hickey, K. D. 344
Hill, C. W. 105, 131, 228
Hill, R. R., Jr. 78, 228
Hillson, C. J. 106, 110
Hilton, J. W. 74, 77, 407
Hlubik, J. G. 85
Hobbs, B. A. 405
Hodgson, J. L. 209, 340
Hoffa, H. E. 94
Hoffman, G. H. 66
Hoffman, L. E. 263
Hogan, D. P. 170, 377
Hogg, J. H. 164
Hogg, R. 207, 305
Hogler, R. L. 421
Hoke, J. H. 292
Holcomb, E. J. 257
Holdsworth, D. W. 230
Holl, J. W. 66
Holland, H. D. 233
Hollis, T. M. 103, 106, 340
Holmes, B. C. 396, 403
Holmes, C. 199
Holway, J. L. 278
Hoover, J. R. 74, 77

Hopfensperger, J. 93
Hopkins, D. E. 313
Hopper, A. K. 103, 131, 228
Hopper, J. E. 103, 131, 228
Horrocks, W. D., Jr. 137
Hoshower, L. B. 112
Hosler, C. L. 173, 295
Hottenstein, M. P. 111, 327
Howell, P. R. 293
Hower, A. A., Jr. 174, 204
Howett, M. K. 300
Hsiao, M. Y. 319
Hu, T. 176, 327
Hudson, J. R. 362
Huebner, W. 133, 382
Huff, R. E. 282
Hughes, C. A. 386
Hughes, H. G. 215
Hughes, T. G. 289
Hughes, W. J. 60
Hulina, P. T. 154, 188
Hull, L. A. 204
Hultquist, R. A. 392
Hume, K. 199
Hume, R. D. 199
Humphrey, C. R. 170, 378
Hunt, E. E., Jr. 87, 228
Hunter, R. P. 282
Hurson, A. R. 154
Hutnik, R. J. 219
Hutton, R. F. 69
Hyman, D. 148
Hyman, R. W. 131, 228, 300
Hymer, W. C. 101
Ickes, B. W. 176
Inserra, L. 91
Irwin, M. J. 156
Isom, H. C. 131, 300
Ivanits, L. J. 151
Jablonsky, S. F. 111
Jackman, L. M. 137
Jacob, S. T. 131, 228, 332
Jacobs, H. R. 288
Jacobs, R. R. 357
Jacquette, D. 334
Jaffe, A. J. 111
James, D. G. 282
Jang, S. J. 382
Janota, C. P. 60
Jansma, J. D. 69
Jarrett, A. R. 74, 77, 207
Jech, T. 282
Jefferson, L. S., Jr. 131, 340
Jenkins, J. P. 62, 148
Jenkins, R. G. 207, 226
Jennings, S. R. 300
Jensen, D. W. 66
Jester, W. A. 319
Johnson, D. W. 164
Johnson, G. G., Jr. 156, 382
Johnson, H. C., Jr. 185
Johnson, J. A. 357
Johnson, J. E. 164
Johnson, K. A. 101, 311
Johnson, L. J. 78
Johnson, M. P. 378
Johnson, M. W. 78, 228
Johnson, W. W. 219
Johnstone, C. L. 388
Jones, D. R. 271
Jones, M. B. 228
Jordan, B. 313
Jordan, J. 137
Jorgenson, J. A. 164
Joseph, J. H. 396, 403
Joshi, S. 266, 289
Joukovsky, N. A. 199
Jung, G. A. 78
Juravich, T. J. 421
Jurs, P. C. 137
Kabel, R. L. 135, 207
Kant, K. 156
Kanwal, R. P. 282
Kao, T. 311, 346
Karakawa, W. W. 101
Kasturi, R. 154, 187
Katkin, D. 62, 148
Kavanaugh, J. F. 405
Kaynak, E. 122
Kazes, E. 337
Keat, D. B. II 161, 376
Keener, C. S. 107, 110, 174
Keil, R. L. 105, 131, 228
Keith, A. D. 311
Kelley, E. J. 111
Kelley, L. S. 321
Kelley, W. J. 399
Kelz, J. W. 161
Kemal, S. 334
Kendall, B. R. F. 337
Kendall, W. A. 78, 346
Kenkel, D. S. 176
Kenney, W. L. 209, 341
Kensinger, R. S. 85, 323, 341
Kephart, K. B. 85
Kerlin, R. L. 60
Kerrick, D. M. 233, 236
Kersavage, P. C. 219
Ketz, J. E. 111
Keune, M. E. 243
Kevelson, R. 334
Keynes, E. 350
Khoo, I. 187
Khosrowpour, M. 126
Kibler, D. F. 140, 206, 207, 327
Kiernan, M. 199
Kiffer, T. E. 199
Kilara, A. 217, 323
Kilareski, W. P. 140
Killian, G. J. 85, 340
Kim, K. C. 174, 204
King, M. R. 348, 350
Kingsbury, H. F. 90
Kingsolver, C. H. 343
Kinser, W. 93
Kirkland, J. 327
Kiusalaas, J. 192, 195
Klein, P. A. 176
Kleindorfer, G. B. 111, 327
Klevans, E. H. 319
Klimpel, R. R. 305
Kline, D. E. 103
Knievel, D. P. 78, 346
Knight, A. E. 151, 222
Knight, C. G. 174, 208, 230, 327
Knoppers, L. L. 200
Knott, K. 266
Knox, B. E. 381
Koch, P. B. 321
Kochanek, S. A. 350
Kockelmans, J. J. 334
Koehler, R. W. 112
Kohler, J. L. 304, 308
Koide, R. 175, 346
Komarneni, S. 382
Koot, R. S. 111
Kopp, W. L. 151, 243
Kossowsky, R. 192, 196
Kourouklis, S. 392
Kozik, E. 197, 266
Krall, A. M. 282, 327
Kramer, J. H. 62, 148, 378
Kreider, J. W. 131, 300
Kremers, W. K. 175, 392
Kretchmar, R. S. 209
Kris-Etherton, P. M. 323
Kroger, M. 208, 217
Kuhn, G. D. 213, 217
Kulakowsi, B. T. 288
Kulkarni, A. K. 288
Kulkarni, M. 126
Kump, L. E. 233, 236, 239
Kunz, K. S. 187
Kunze, D. 91
Kuo, H. 126
Kuo, K. K. 288
Kur, B. M. 399
Kurland, J. A. 87, 174
Kurre, J. A. 122
Labosky, P. 219
Lachterman, D. R. 334
Lacki, M. J. 215
Ladda, R. L. 228
Laird, D. T. 156
Lakshminarayana, B. 66
Lakhtakia, A. 192, 196
Lallement, G. 282, 327
Lamancusa, J. S. 289
Lamb, D. 208, 260, 295
Lambert, C. 149, 276

Lambert, J. M. 156, 327
Lampe, F. W. 137
Landis, D. 154, 188
Landy, F. J. 357
Lang, C. M. 228, 270
Lang, G. 93
Lang, L. G. 337
Langston, C. A. 233, 241
Lannin, J. S. 337, 381
LaNoue, K. F. 131, 317, 340
Lanyon, L. E. 78, 175
LaPorte, R., Jr. 365
La Rouche, R. D. 135
Larson, T. D. 140, 348
Laubach, G. 321
Lauchle, G. C. 60
Launder, B. E. 288
Laurence, P. M. 282
Lavin, P. M. 173, 233, 241
Lawrence, H. 91
Lawton, M. P. 148
Leach, R. M., Jr. 323, 340, 356
Leath, K. T. 343
Lecomte, J. T. 137
Lee, H. 187
Lee, J. 164
Lee, K. Y. 187
Lee, P. S. 112, 327
Lee, R. D., Jr. 365
Lee, S.-L. 156
Lehtihet, A. 266
Leibowitz, H. W. 357
Lenahan, P. M. 192, 195
Lentz, T. M. 389
Leon, D. A. 91
Leonard, R. E. 399
Lerner, J. V. 260
Lesniak, R. J. 396, 403
Leure-duPree, A. E. 83, 317
Levin, J. 164
Levine, S. H. 319, 327
Lewis, A. O. 151
Lewis, P. F. 173, 230
Lewis, R. B. 72, 213
Li, L. C. 282
Li, W. C. 282
Liben, L. S. 357
Lichter, D. T. 378
Liggett, M. H. 126
Lilien, G. L. 111, 327
Lima, R. F., Jr. 151, 383
Lin, C. T. 341
Lin, T. F. 319
Lin, W. 154, 188
Lindsay, B. G. 174, 392
Lindstrom, E. S. 298
Lingis, A. F. 334
Linker, R. W. 253
Lipton, A. 301
Litzinger, T. A. 289
Liu, D. K. 228, 332
Llorens, R. E. 192, 195, 197
Lloyd, T. A. 332
Lombra, R. E. 176
Long, D. A. 140, 206, 208
Long, T. E. 161, 407, 408
Loomis, J. L. 209
Lougy, R. E. 199
Louie, J. N. 233, 239, 241
Love, G. M. 72, 407
Love, N. S. 350
Lowe, J. P. 137
Lowrie, E. B. 421
Lozier, G. G. 251
Lucas, J. A. 209
Luckie, P. T. 304, 305, 327
Luebbers, R. 187
Lukezic, F. L. 343, 346
Lundegren, H. M. 209, 371, 373
Lundy, R. M. 357
Lusht, K. M. 111
Lusk, M. 313
Lyday, L. F. III 383
Lydic, R. 317, 341
Lynch, J. A. 208, 219
Lynch, P. D. 179
Macaluso, J. A. 60
MacEachren, A. M. 230
Machesky, M. L. 233, 236
Mackwell, S. J. 233, 236, 239, 241
MacNab, A. A. 344
MacNeil, J. H. 217
Madden, J. P. 69
Maddox, D. R. 399
Maddox, J. 93
Maddox, R. J. 253
Madjid, A. H. 337
Madsen, J. M. 164, 170
Magenau, J. M. III 122
Mahaffey, J. H. 319
Mahalanabis, A. K. 187, 327
Mahar, W. J. 81, 263
Mahoney, B. K. 357
Maida, A. 156
Makward, C. P. 151, 223
Malcom, R. E. 111
Malone, J. W. 69
Manbeck, H. B. 74, 77
Mander, M. S. 278
Mandle, J. D. 378
Manfull, H. A. 399
Manfull, L. L. 399
Mann, C. W., Jr. 151, 199
Mann, S. H. 148, 248, 276, 327
Mansfield, P. K. 321
Mansfield, R. B. 282
Marasas, W. F. O. 344
Marciniak, P. D. 60
Mark, M. M. 348, 357
Mark, V. 223
Marks, E. 182
Marks, G. W. 141
Marlow, H. L. 112
Marme, D. R. 399
Maroncelli, M. 137
Marshall, H. G. 78, 228
Martin, J. E. 357
Martin, L. F. 341
Martinez-Brawley, E. E. 348, 378
Martorana, S. 64, 250
Martz, J. D. III 350
Maserick, P. 282
Mashaly, M. M. 340, 356
Maslak, P. 137
Mason, J. M. 141
Mason, M. E. 217
Massagli, M. P. 378
Mast, M. G. 217
Mastro, A. M. 228, 298
Mastrofski, S. D. 62, 148
Mathews, J. D. 188
Matson, F. R. 87
Matsushima, S. 98
Matthews, B. 93
Matthews, C. R. 137
Maughmer, M. D. 66
Mauner, G. 96
Mayers, S. P., Jr. 149, 208, 249
Mayhew, R. 93
Maynard, J. D. 60, 337
McAdams, J. R. 200
McAfee, J. K. 386
McAlexander, R. H. 69
McCammon, D. F. 60
McCammon, M. 282
McCammon, R. D. 337
McCarl, R. L. 101, 340
McClearn, G. E. 228, 260, 323, 357
McClure, R. M. 140
McCormick, B. W., Jr. 66
McCormick, L. H. 174, 219
McCubbin, T. K., Jr. 337
McDaniel, O. H. 60, 289
McDaniel, S. T. 60
McDonnell, A. J. 140, 174, 206, 208
McGrath, R. T. 319
McHale, S. M. 260
McHale, W. J. 93
McInerney, J. J. 103
McKenna, C. K. 208, 368
McKenna, F. R. 185
McKinstry, H. A. 133, 381
McMillen, J. B. 344
McMurry, S. A. 253
McMurtry, G. J. 187, 197, 327
McNair, C. J. 112
McNally, T. P. 399
McNitt, R. P. 192, 195
McSweeney, W. T. 327
McWhirter, J. R. 135

Mecholsky, J. J., Jr. 133
Medeiros, D. J. 266, 327
Melander, E. R. 112
Melloy, B. J. 266, 327
Melton, R. E. 219
Melton, R. G. 66
Menotti, F. R. 60
Mentzer, M. S. 122
Merica, C. A. 90
Merkle, C. L. 289
Merrill, W. 344
Merriman, L. C. 313
Merritt, T. L. 85
Mesazaros, P. I. 98
Messier, R. 192, 195, 381
Messing, G. L. 133, 381
Metzner, J. J. 154, 187
Meyer, D. J. 74, 77
Micci, M. M. 66
Michelman, J. E. 112
Michels, J. W. 87
Miles, J. A. 111
Miljkovic, M. 105
Miller, A. C. 141, 206, 208
Miller, D. D. 313
Miller, E. L. 271
Miller, E. W. 230
Miller, J. A. 148
Miller, J. H. 111
Miller, K. J. 217, 346
Miller, P. J. 313
Miller, S. M. 396
Miller, S. N. 403
Miller, W. 156
Miller, W. R. 197
Milliron, V. C. 111
Millman, R. W. 112
Milner, G. R. 87
Minard, R. D. 137
Mitchell, J. A. 187
Mitchell, R. B. 107, 341
Mitchell, W. J. 282
Mitzel, H. E. 182, 357
Modest, M. F. 289
Moeser, J. 313
Mollo, R. A. 188
Moore, D. E. 374
Moore, J. W., Jr. 151, 200
Moore, K. M. 250, 348
Moore, M. G. 64
Moorman, G. W. 344
Morgan, R. S. 311
Moritz, F. A. 278
Morrill, W. T. 87, 398
Morris, P. D. 282
Morris, P. J. 66
Morrow, C. T. 74, 77
Mortensen, J. H. 72, 407
Mortimer, K. P. 250
Mortimore, G. E. 340
Morton, S 112
Mozingo, R. R. 141
Muan, A. 233, 236, 292
Mulay, L. N. 381
Mulford, C. J. 200
Mulhern, J. J. 275
Mullen, G. L. 282
Muller, L. D. 85, 323
Mullin, C. A. 346
Mumma, R. O. 204, 340
Mumma, S. A. 89, 346
Munger, B. L. 83, 131, 228, 317
Munzenrider, R. F. 208, 368
Murphy, B. A. 350
Murphy, D. J. 74, 77, 213
Murti, V. N. 126
Murty, V. N. 197, 208
Mutchler, J. E. 378
Mutmansky, J. M. 304, 308, 327
Myers, B. L. 112
Myers, D. J. 350
Myers, W. L. 174, 219, 327
Nagarajan, R. 135
Narayana, K. T. 156
Natarajan, N. 156
Nechemias, C. 368
Neff, W. H. 107, 341
Neffson, R. 93
Neisworth, J. T. 386
Nelson, J. P. 176, 327, 348
Nelson, K. E. 273, 357, 398
Nelson, M. R. 164
Nelson, N. M. 228
Nelson, P. E. 344
Nelson, R. C. 209
Nelson, R. R. 228, 344
Nesselroade, J. R. 260
Neu, J. 273, 389
Neubert, V. H. 60, 192, 195
Newnham, R. E. 133, 381
Nicely, R. F., Jr. 164
Nicholas, W. C. 209, 341
Nichols, J. S. 278
Nisbet, J. S. 187
Nixon, B. T. 311, 346
Noble, M. E. 357
Nolan, J. F. 164
Norgren, R. 317
Norling, F. J. 365
Norris, V. P. 278
Norton, G. P. 222
Nousek, J. A. 99
Novack, R. 112
Nti, K. O. 111
O'Connor, M. L. 85
O'Connor, R. E. 350
Oh, B. Y. 337
Ohmoto, H. 233, 236
Olivero, J. J., Jr. 173, 295
Olofson, R. A. 137
Olsen, L. K. 246
Olson, J. C. 111
Olson, J. E. 282
Ord, J. K. 111, 327, 392
Osseo-Asare, K. 292, 305
Oswald, J. W. 344
Ott, R. W. 94
Owens, R. M. 156
Page, D. N. 337
Page, R. B. 83, 317
Painter, P. C. 353
Pakzad, S. H. 154, 188
Palermo, D. S. 273, 357, 398
Palmer, H. B. 226
Pangborn, R. N. 192, 195, 382
Panofsky, H. A. 295
Pantano, C. G. 133, 381
Parberry, I. 156
Pardalos, P. 156, 327
Parizek, R. R. 208, 233, 239
Park, W. H. 289
Parkin, B. R. 66
Parks, S. J. 276
Parkum, K. H. 126
Parsonage, W. H. 149
Parsons, P. R. 278
Partenheimer, E. J. 69
Pashek, R. D. 111
Passananti, G. T. 332
Passmore, D. L. 64, 304, 407, 408
Paternost, J. 420
Patil, G. P. 174, 392
Patterson, A. H. 62, 148, 276
Patterson, J. S. 81, 263
Patton, W. H. 208, 405
Pavlik, J. V. 278
Pazur, J. H. 101, 346
Pearson, D. L. 107, 174
Pearson, R. 278
Peavler, T. J. 151, 383
Pechersky, M. J. 192, 196
Pedersen, D. J. 260, 389
Pegden, C. D. 266, 327
Pegg, A. E. 131, 340
Pell, E. J. 344, 346
Pellegrin, R. J. 378
Pennock, R. 78
Pennypacker, S. P. 344
Pepe, D. 93
Perman, L. 378
Person, S. R. 228, 311
Persson, S. P. E. 74, 77
Pertalion, A. J. 399
Petersen, G. W. 78, 208
Petrie, H. L. 289
Peuquet, D. J. 230
Pfaff, D. W. 278
Phalan, R. T. 112
Phelps, L. B. 304, 308
Phillips, A. T. 101
Phillips, G. M. 388
Phillips, J. 135
Pickering, H. W. 292

Pierce, R. A. 260
Pierce, W. S. 103
Pillay, K. K. S. 319
Pionke, H. B. 78
Pitts, C. W. 204
Playdon, D. 91
Pliva, J. 337
Plomin, R. 260
Polo, S. R. 337
Pootjes, C. F. 298
Porter, J. C. 96
Porter, R. D. 228, 298, 311
Porter, S. 93
Porterfield, N. H. 271
Pothen, A. 156
Powell, C. A. 344
Prakash, M. S. 185
Pratt, J. R. 175, 215
Prebish, C. S. 420
Preisner, R. 243
Preston, D. B. 321
Prewitt-Diaz, J. O. 164, 376, 398
Price, J. G. 199
Price, R. G. 334
Prinz, P. M. 144, 273, 398
Pritchard, W. G. 66, 282
Prout, J. H. 60
Prybyla, J. S. 176
Puri, V. M. 74, 77
Pursell, R. A. 107, 110
Purushothaman, S. 156
Pytel, A. 192, 196
Pytel, J. L. 192, 196
Queeney, D. S. 64, 192, 195
Radovic, L. R. 226
Raffel, M. W. 149, 248
Rahman, S. 365
Rajotte, E. G. 204
Ramani, R. V. 304, 308, 327
Rambeau, J. M. 200
Ramirez, J. 368
Ramsey, L. W. 98
Rannels, D. E., Jr. 131, 340
Rao, S. 111
Rapp, F. 228, 300
Ravizza, R. J. 357
Ray, A. 289
Ray, W. J. 357
Rayman, J. R. 161
Rayner, R. K. 122
Reddy, C. C. 208, 323, 405
Reed, J. R. 141, 206
Reethof, G. 60, 289
Regan, R. W. 141, 206, 208
Regev, A. 282
Rekart, D. M. 273, 389
Remick, F. J. 319
Retford, L. 263
Reutzel, E. T. 111, 327
Reyburn, J. H. 72, 213
Reyes, A.D. 151, 200
Richards, B. 407, 408
Richards, W. A. 197
Richey, H. G., Jr. 137
Richman, I. 81, 263
Richman, M. S. 197
Ricker, D. W. 60
Riew, J. H. 176
Rigby, P. H. 111, 327
Rindone, G. E. 133
Rippey, J. N. 278
Risius, M. L. 78, 228
Ritti, R. R. 62, 148, 276
Roberti, Paolo 156
Roberts, B. 176
Roberts, D. M. 182
Roberts, M. J. 176
Robinett, R. W. 337
Robinson, G. E. 319
Robinson, J. W. 187
Robinson, W. C. 176
Rodgers, A. L. 230
Rodgers, A. T. 199
Rodgers, J. D. 176, 348
Rogers, D. M. 383
Rogers, T. H. 199
Rogowski, A. S. 78, 208
Romaine, C. P. 228, 344
Rooney, J. F. 362
Rose, A. W. 233, 236
Rose, G. D. 105, 131
Rose, R. C. 323, 340
Rosen, S. H. 334
Rosenberg, G. 103
Rosenberg, R. 176
Rosenberger, J. L. 174, 392
Rosenshine, M. 266, 304, 327
Ross, J. M. 64
Ross, W. J. 187
Rothenbacher, H. 405
Rousch, W. B. 323, 327, 356
Rovine, M. 260
Roy, D. M. 381
Roy, M. S. 313
Roy, R. 233, 236, 381
Roy, T. D. 292
Royse, D. J. 344
Rozen, M. E. 176
Rubba, P. A. 164
Ruhl, K. L. 386
Rung, D. C. 282
Runt, J. P. 353
Rush, J. S. 278
Russell, D. W. 188
Rutkowski, J. 313
Ruud, C. O. 192, 196, 382
Ruzyllo, J. 188
Ryan, T. A., Jr. 392
Ryba, E. R. 292
Sabock, R. J. 209
Sachs, C. E. 374
Sachs, R. 282
Sailer, L. D. 122
Salamon, N. J. 192, 195
Salvia, A. A. 197
Salvia, J. A. 376, 386
Sampson, D. H. 98
Samuelson, L. W. 176
Sanders, P. L. 344
Sanders, W. T. 87
Santavicca, D. A. 289
Sanvido, V. E. 90
Saradhi, V. 126
Satterlee, L. D. 217, 323
Saunders, M. C. 204
Scanlon, A. 141
Scanlon, D. C. 72, 407
Scannell, R. J. 209
Scaroni, A. W. 226
Schaie, K. W. 260, 357
Scheetz, B. E. 208, 382
Schein, R. D. 344
Schenck, G. H. K. 208, 302, 304
Schengrund, C. 105, 131, 228, 317
Schiller, R. W. 197
Schisler, L. C. 344, 346
Schlegel, R. A. 228, 311
Schmalstieg, W. R. 273, 420
Schmalz, R. F. 173, 233, 239
Schmidt, F. W. 289
Schnabel, R. R. 78
Schneeman, P. H. 151, 200
Schnitger, G. 156
Schobert, H. H. 226
Scholz, R. W. 323, 340, 405
Schoolwerth, A. C. 341
Schrader, W. J. 111
Schultz, J. C. 175, 346
Schurer, E. I. 243
Schutjer, W. A. 69, 170, 374
Schwartz, A. M. 94
Schwartz, L. L. 182
Schwartz, S. 199
Seaburg, P. A. 89
Seaman, N. L. 295
Secor, M. J. 200
Secor, R. A. 199
Seibel, R. 182, 357
Selander, R. K. 107, 228
Seliga, T. A. 188
Selzer, J. L. 200
Sen, A. 137
Settles, G. S. 289
Severs, W. B. 317, 332
Shafer, E. L. 371, 373
Shalloway, D. I. 311
Shamma, M. 137
Shannon, B. M. 323
Shannon, J. C. 228, 257, 346

Shapiro, A. F. 111
Shapiro, D. 176
Sharfman, M. P. 112
Sharma, M. G. 103, 192, 195
Sharp, M. W., Jr. 164
Sharpe, W. E. 175, 208, 219
Shaw, M. D. 74, 77
Shaw, P. B. 337
Shea, G. S. 112
Shea, J. B. 209
Shellenberger, P. R. 85, 213
Shenk, J. S. 78, 228
Sherwood, R. T. 343
Shiman, R. 105, 131, 228
Shipman, R. D. 174, 219
Shipp, R. F. 78
Shirer, H. N. 295
Shobaken, B. R. 93
Short, E. C. 164
Shortle, J. 70, 327
Shotland, R. L. 357
Shoup, J. F. 197
Shrigley, R. L. 164
Shrout, T. R. 382
Shung, K. K. 103
Shyamasundar, R. 156
Sibley, D. A. 282
Sibul, L. H. 60
Siegel, H. S. 340, 356
Signorella, M. L. 357
Silverman, D. P. 253
Simkins, P. D. 170, 230
Simko, R. A. 208, 368
Simkovich, G. 208, 292, 381
Simpson, S. G. 282
Sims, H. P., Jr. 111
Sims, L. S. 323
Sinha, A. 289
Skelly, J. D. 174
Skelly, J. M. 344
Skok, J. E. 208, 368
Skudrzyk, E. J. 60
Slingerland, R. L. 233, 239
Small, W. M. 293
Smilowicz, Z. 174, 204
Smith, B. J. 70, 164
Smith, C. B. 257
Smith, C. H. 111
Smith, D. K. 233, 236, 381
Smith, D. L. 278
Smith, E. 96
Smith, G. A. 337
Smith, H. C. 66
Smith, J. E. 323
Smith, R. A. 209
Smith, R. B. 289
Smith, R. W. 373
Smith, S. H. 313
Smyer, M. A. 260
Smyth, T., Jr. 204, 311
Snetsinger, R. J. 204, 213
Snider, M. T. 341
Snipes, W. C. 228, 311
Snow, C. C. 111
Sommer, H. J. III 289
Sommese, L. B. 93
Sopper, W. E. 174, 208, 219
Soto, L. D. 164
Soyster, A. L. 266, 304, 327
Spear, K. E. II 133, 381
Specht, L. W. 85
Spector, D. J. 131, 228, 300
Spence, L. D. 348, 350
Spielvogel, J. J. 253
Spychalski, J. C. 111
St. Pierre, R. W. 246
Stabb, M. S. 383
Standler, R. 188
Starling, J. L. 78, 228
Stauffer, J. R., Jr. 176, 213, 219
Stebbins, P. E. 253
Steele, W. A. 137
Stefanou, S. 70, 327
Steffensmeier, D. J. 378
Stein, J. J. 188, 197
Steiner, K. C. 174, 219, 228
Stenger, A. J. 111
Stephens, B. M. 421
Stephens, J. L. 389
Stephenson, A. G. 107, 110, 174, 346
Stephenson, J. E., Jr. 93
Stern, R. 60
Stern, R. M. 357
Stevens, J. M. 348, 365
Stevens, S. E., Jr. 174, 228, 298, 311, 346
Stewart, B. 313
Stifter, C. A. 260
Stinson, R. F. 72, 257, 407
Stoedefalke, K. G. 209
Stokes, C. S. 170, 374
Storm, G. L. 215, 219
Stout, W. L. 78
Strasser, G. F. 151, 243
Stratton, V. N. 357
Strauss, C. H. 219
Streit, D. A. 289
Strumillo, W. A. 90
Stuart, A. D. 60
Stuart, B. C. 149, 248
Stubican, V. S. 133, 381
Suhr, N. H. 233, 236
Sujan, H. 112
Sujan, M. 112
Summers, L. H. 89
Summy-Long, J. Y. 317, 332
Sun, E. Z. 253
Suomi, S. J. 260
Susman, E. J. 321
Susman, G. I. 112, 304
Susskind, J. L. 396, 403
Swadener, E. B. 164
Sweeney, J. R. 253
Sweeney, T. W. 323
Swisher, J. D. 161
Szauter, P. G. 105, 131, 228
Takei, Y. 185, 378
Tanabe, T. Y. 85
Tarbell, J. M. 103, 135
Tawney, J. W. 386
Taylor, M. C. 185, 348, 378
Taylor, M. E. 246
Taylor, W. D. 228, 311
Templeton, W. C., Jr. 78
Tenser, R. B. 300, 317
Tershak, D. R. 298
Terza, J. V. 176
Tevethia, M. J. 131, 228, 300
Tevethia, S. S. 131, 300
Thazhuthaveetil, M. J. 154, 188
Theodorson, G. A. 378
Therrien, C. D. 107, 110, 228
Thies, J. B. 112
Thigpen, K. A. 151, 200
Thomas, H. 357
Thomas, H. R., Jr. 141, 327
Thomas, T. M. 263
Thomchick, E. A. 112
Thompson, C. W. 200
Thompson, D. B. 217, 323
Thompson, D. E. 66
Thompson, J. G. 209
Thompson, M. P. 217
Thompson, W., Jr. 60, 192, 195
Thomson, D. W. 173, 208, 295
Thomson, J. S. 64, 374
Thornton, C. P. 173, 233, 236
Thrower, P. A. 292
Thwaites, T. T. 337
Thynell, S. T. 289
Tichy, J. 60, 89
Tien, M. 101, 299
Tierney, W. G. 251
Tischler, N. M. 81
Tomiyama, K. 188, 327
Toombs, W. 64, 250
Tosch, W. C. 330
Toth, E. J. 151, 200
Toulson, S. C. III 313
Toussoun, T. A. 344
Towns, K. 362, 403
Townsend, B. S. 164
Toy, D. R. 112
Traverse, A. 107, 110, 173, 233, 239
Travis, J. W. 344
Tressler, R. E. 133
Trethewey, M. W. 289
Trinkley, W. B. 313

Triolo, A. A. 383
Trueblood, C. R. 164
Tsach, U. 103, 289
Tsong, T. T. 337
Tsugawa, A. G. 334
Tu, C. D. 101, 228, 311
Tukey, L. D. 257
Turgeon, A. J. 78
Turns, S. R. 289
Twark, R. D. 112
Twight, B. W. 219
Tyworth, J. E. 112
Tzilkowski, W. M. 219
Uhl, C. 107, 110, 175
Ultman, J. S. 103, 135
Untrauer, R. E. 141
Unz, R. F. 141, 174, 206, 208
Upcraft, M. L. 161
Uricchio, W. C. 278
Usher, P. D. 98
Valenzuela, H. M. 188
Van Dommelen, D. B. 94
Van Herik, J. 420
Van Horn, J. 374
Vannice, M. A. 135
Vannucci, R. C. 317
Varadan, V. K. 60, 192, 195, 381
Varadan, V. V. 60, 192, 195, 381
Varga, G. A. 85, 323
Vaserstein, L. N. 282
Vasilatos-Younken, R. 356
Vastola, F. J. 226
Vastyan, E. A. 421
Vaught, C. G. 334
Vedam, K. 337, 381
Vesell, E. S. 228, 332
Vicary, J. 321
Vicente, A. 223, 273, 398
Villafranca, J. J. 137
Vogely, W. A. 302, 304
Voight, B. 233, 239, 308
von Eye, A. 260
Vora, G. 112
Vrentas, J. S. 135
Waddington, D. V. 78
Wagner, C. H. 197, 208
Walden, D. 151, 199
Walker, P. L., Jr. 226
Walker, P. N. 74, 77
Walsh, E. J. 378
Walsh, W. F. 62
Walter, J. E. 289
Walters, E. 96
Walters, S. E. 197, 208
Wambold, J. C. 289
Wang, M. C. 141
Wang, P. 176
Wangsness, P. J. 85, 323, 340
Ware, R. P. 282
Warland, R. H. 170, 374, 348
Warner, T. T. 295
Warren, J. M., Jr. 357
Wartick, S. L. 112
Wartik, T. 137
Waterhouse, W. C. 282
Watkin, D. G. 126
Watschke, T. L. 78
Watson, A. K. 389
Wayne, C. E. 282
Weaver, R. D. 69, 327
Webb, R. L. 289
Webster, D. L. 87
Webster, G. S. 87
Webster, P. J. 295
Wedler, F. C. 101
Weedman, D. W. 98
Weidner, W. A. 103
Weigl, B. 199
Weimer, W. B. 357
Weiner, F. F. 144
Weinreb, S. M. 137
Weintraub, S. 151, 199
Weis, S. F. 64, 256, 407
Weiss, B. 383
Weiss, K. M. 87, 170, 228
Weisz, J. 228, 317
Welch, F. G. 407, 408
Weller, B. R. 122
Welliver, P. W. 164
Wells, R. 282, 327
Welsh, W. A. 197
Wernstedt, F. L. 173, 230
West, H. H. 141, 304
West, J. P. W. 199
West, P. N. 151, 199
Westby, D. L. 378
Wetheimer, M. 389
Wheeler, A. G., Jr. 204
White, D., Jr. 135
White, E. R. 161
White, J. W. 257
White, W. B. 208, 233, 236, 381
White, W. J. 228
Whitfield, C. F. 131, 340
Whitmore, J. J. 337
Whittam, T. S. 107, 175
Wickersham, E. W. 107, 246, 340
Wideman, R. F., Jr. 341, 356
Wigdahl, B. L. 131, 301, 317
Wilkinson, K. P. 374
Willenbrock, J. H. 141, 304, 327
Williams, A. V. 170, 230, 327
Williams, E. G. 173
Williams, F. M. 107, 175
Williams, W. 72, 407
Williamson, J. A. 321
Williamson, W. O. 133
Willits, F. K. 374
Willower, D. J. 179, 327
Wilson, B. G. 93
Wilson, D. T. 112
Wilson, L. L. 85, 228
Wilson, R. A. 405
Winograd, G. 389
Winograd, N. 137
Winston, B. N. 278
Witham, F. H. 257, 346
Witteman, H. 389
Wojchowski, D. M. 299, 311
Wolf, G. D. 263
Wolf, M. H. 263
Wolff, D. 263
Wolford, C. 122
Wolgemuth, C. H. 289
Wood, R. A. 112
Woolford, E. M. 87, 273, 398
Woolridge, J. R. 112
Wright, H. S. 323
Wright, J. E., Jr. 228
Wright, L. A. 173
Wronski, C. R. 188, 192, 195, 381
Wu, J. Y. 131, 317, 340
Wuest, P. J. 213, 344
Wyatt, N. J. 389
Wysk, R. A. 266
Yaari, M. 223
Yahner, R. H. 175, 213, 219
Yang, C. 188
Yang, V. 151, 289
Yapa, L. S. 230
Yarnal, B. M. 173, 230
Yavuzkurt, S. 289
Yeh, R. V. 323
Yendol, W. G. 204
Yesalis, C. E. 246
Yevick, D. O. 188
Yin, Z. 282
Yoder, E. P. 72, 407
Yoder, M. D. 313
Yoo, B. S. 176
Young, D. L. 271
Young, E. W. 321
Young, G. S. 295
Young, M. L. 368
Younken, R. V. 323, 341
Yu, F. T. S. 187
Yu, L. C. 248
Yucelt, U. 126
Zagon, I. S. 83, 131, 228, 317
Zamrik, S. Y. 192, 195
Zarit, S. H. 260
Zarkower, A. 299, 405
Zelinsky, W. 170, 230
Zelis, R. F. 103, 340
Ziegenfuss, J. F., Jr. 368
Ziegler, V. L. 243
Zimmerman, L. N. 228, 299
Zuritz, C. A. 74, 77

SUBJECT INDEX

Academic Credit and Employment, 42
Academic Degrees, 6, 38, 46, 52
Academic Divisions, 3
Academic Officers, 3
Academic Status, Full-Time, 42
Academic Status, Part-Time, 42
Accounting Courses
  At Behrend, 123
  At University Park, 115
Acoustics, 60
Additional Specific Requirements
  D.Ed. Degrees, 50
  Master's Degrees, 53
  Ph.D. Degrees, 49
Administration (Graduate School), 17
Administration (University), 3, 17
Administration of Justice, 62. *See also* Community Systems Planning and Development
Administrative Centers of the Graduate School, 4
Administrative Officers of the Graduate School, 9
Admission
  Graduate School, 34
  Doctoral Programs, 46
  Master's Programs, 52
  Provisional, 37
Adult Education, 64
Advanced Degrees Offered, 38
Advisers, 39, 47, 53
Aerospace Engineering, 66
Agricultural Economics, 69
Agricultural Education, 72
Agricultural Engineering, 74
Agricultural Mechanization, 77
Agriculture, General, Courses, 410
Agronomy, 78
Aid, Financial, *See* Student Aid
American Studies (Capital), 81
American Studies (U.P.), 410
Anatomy, 83
Animal Industry, *See* Animal Science
Animal Nutrition, *See* Nutrition
Animal Science, 85
Anthropology, 87
Application and Admission Procedures, 34
Architectural Engineering, 89
Architecture, 91
Art, 93
Art Education, 94
Art History, 96
Arts, The, 25
Assistantships, 30
Astronomy, 98
Athletic Facilities, *See* Recreational and Athletic Facilities
Auditing Classes, 41

Behavioral Science Courses (Capital), 363
Behavioral Science Courses (U.P.), 411
Behrend College, *See* Penn State Erie, 4, 17
Benefits and Privileges, 43
Bicycles on Campus, *See* Motor Vehicle Regulations
Biochemistry, 101
Bioengineering, 103
Biological Chemistry, 105
Biology, 106
Biophysics, *See* Molecular and Cell Biology
Black Studies, 411
Botany, 110
Business Administration Courses (U.P.), 115
Business Administration Major
  At Behrend, 122
  At Capital, 129
  At University Park, 111
Business Courses (Capital), 128
Business Law Courses (U.P.), 116
Business Logistics Courses (U.P.), 116

Calendar, 10
Candidacy Examination, 48
Capital College, *See* Penn State Harrisburg, 4, 17
Career Development and Placement Center, 27
Cars on Campus, *See* Motor Vehicle Regulations
Cell and Molecular Biology, 131
Ceramic Science, 133
Ceramic Science and Engineering Courses, 134
Certificate Students, 37
Certificates, Pennsylvania Department of Education, 59
Change of Degree or Program, 44
Charges, *See* Specific Charges
Chemical Engineering, 135
Chemistry, 137
Chinese Courses, 411
Civil Engineering, 140
Classes
  Schedule of, *See* Schedule of Courses
  Visiting and Auditing, 41
Classics Courses, 411
Classification of Students, 37
College of Medicine, *See* Hershey
Commencement, *See* Graduation
Committees, Doctoral, 47
Committees, Standing, of the Graduate Council, 16
Common Courses, 41
Communication and Foreign Language Competence, 48
Communication Disorders, 144
Communications, *See* Mass Communications, 278
Communications Courses (Behrend), 123
Community Systems Planning and Development, 148
Comparative Literature, 151
Comparative Medicine Courses, 271
Comprehensive Examination, 49, 51

Computation Center, 20
Computational Fluid Dynamics, 412
Computer Engineering, 154
Computer Science, 156
Computing Facilities, *See* Specialized Computing Facilities
Concurrent Candidacies, 44
Conduct, Standards of, 46
Continuing Education Credits, 41
Continuity of Registration, 39
Continuous Registration, Ph.D., 50
Cost of Attendance, 28
Counseling Psychology, 160
Counseling Services, 27
Counselor Education, 161
Course Numbering System, 40
Course
  Common, 41
  Schedule of, 41
Credit by Examination, *See* Examinations
Credit Load, *See* Academic Credit and Employment
Credits
  Continuing Education, 41
  Graduate, 40
  Off-Campus, 47
  Staff Employee, 43
  Transfer, 36, 47, 53
Cultural Events, *See* Arts, The
Curriculum and Instruction, 164
Curriculum and Supervision Courses, 165

Dairy Science, *See* Animal Science
Deadlines, 35, *See also* Calendar
D.Ed. — Additional Specific Requirements, 50
Degree, Change of, 44
Degree Student (Definition of), 37
Degrees, 6, 38, 46, 52
Demography, 170
Developmental and Remedial Reading, 172
Disabled Student Services, 26
Doctoral Committees, 47
Doctoral Degrees, 46
Driving on Campus, *See* Motor Vehicle Regulations

Earth and Mineral Sciences Courses, 412
Earth Sciences, 173
East Asian Studies Course, 412
Ecology, 174
Economics, 176
Economics Courses
  At Behrend, 123
  At Capital, 129
Education Certificate Candidates, Pennsylvania Department of, 59
Educational Administration, 179
Educational Psychology, 182
Educational Theory and Policy, 185
Electrical Engineering, 187
Elementary Education, Capital, *See* Teaching and Curriculum
Elementary Education, University Park, *See* Curriculum and Instruction
Employee Credit Status, 43
Employment and Loan Programs, 32
Employment, Student, 30, 33, 43
Engineering Acoustics, *See* Acoustics
Engineering Courses, 412
Engineering Mechanics, 192
Engineering Science, 195
Engineering Science, Off-Campus Programs, 197
English, 199
English Proficiency of International Students, *See* International Students
Entomology, 204
Environmental Engineering, 206
Environmental Pollution Control, 207
Environmental Resource Management Courses, 412
Examinations, 37, 53
  Candidacy, 48
  Comprehensive, 49, 51
  Credit by, 37, 53
  Final Oral, 49
  Graduate Record, 37, 53 (*see also* Qualifications)
Exercise and Sport Science, 209
Expenses, *See* Tuition and Charges
Extension, *See* Continuing Education
Extension Education, 213

Facilities, *See* Research Facilities
Facilities, Recreational and Athletic, 24
Faculty, Graduate, 16
Federal Student Assistance Satisfactory Academic Progress Standard, 32
Fees, *See* Tuition and Charges
Fellowships, 30
Film and Video, 214
Final Oral Examination, 49
Finance Courses
  At Behrend, 124
  At Capital, 129
  At University Park, 117
Financial Aid, *See* Student Aid
Fish and Wildlife Sciences, 215
Food Science, 217
Food Service, *See* Housing and Food Service
Foreign Language, *See* Communication and Foreign Language Competence
Foreign Students, *See* International Students
Forest Products Courses, 221
Forest Resources, 219
Forestry Courses, 221
French, 222
Fuel Science, 226

Full-Time Academic Status, 42
Full-Time Employment Off Campus, 43

General Information, 16
Genetics, 227
Geochemistry and Mineralogy, 236
Geography, 230
Geology, 239
Geophysics, 241
Geosciences, 233
German, 243
Gerontology, 412
Governance, Graduate School, *See* Graduate Council
Grade-Point Average
  Doctoral Degrees, 47
  Master's Degrees, 52
Grading System, 43
Graduate Administrative Centers, 4
Graduate Assistantships, 30
Graduate Commons, Kern, 23
Graduate Council, 8, 16
Graduate Credits, 40
Graduate Degree Requirements, 46
Graduate Faculty, 16
Graduate Life, 23
Graduate Program Locations, 17
Graduate Programs and Degrees Conferred, 6
Graduate Programs, Faculty, and Courses, 60
Graduate Record Examination, *See* Examinations
Graduate Student Association, 23
Graduation, 45
Graduation, 45
  In Absentia, 45
  Requirements, 45
Grants-in-Aid, Graduate School Tuition, 31
Greek Courses, 412
Guests of the University, 36
Guidelines for Total Allowable Resources, 33

Health Education, 246
Health Insurance, 27
Health Planning and Administration Courses, 248
Health Planning and Administration Program, *See* Community Systems Planning and Development
Health Services for Children, 27
Health Services, University, 26
Hershey, The Milton S. Medical Center, 4, 18
Higher Education, 250
History (Major), 252
History (University), 16
Home Economics Education, 256
Horticulture, 257
Hotel, Restaurant, and Institutional Management Courses, 277
Housing and Food Service, 25
Human Development and Family Studies, 260
Human Development Courses, 413
Humanities, 263
Humanities, Doctoral Minor, 413

Individual and Family Studies Courses, 261
Industrial Education Courses, 409
Industrial Engineering, 266
Instructional Systems Courses, 166
Insurance Courses, 117
Insurance, Health, 27
Intercollege Majors, 6-7. *See also* Special Interdisciplinary Majors
Interdisciplinary Majors, Special, 38
International Business Courses
  At Behrend, 124
  At Capital, 130
  At University Park, 118
International Students
  Admission of, 35
  Office of, 24
Italian Courses, 413

Japanese Courses, 413
Justice, Administration of, *See* Community Systems Planning and Development

Kern Graduate Commons, 23
King of Prussia Center for Graduate Studies, *See* Penn State Great Valley

Labor and Industrial Relations Courses, 413
Laboratory Animal Medicine, 27
Landscape Architecture, 271
Latin Courses, 414
Liberal Arts Courses, 414
Libraries, *See* University Libraries
Library Studies Courses, 414
Linguistics, 273
Literary Theory, Criticism, and Aesthetics, Doctoral Minor in, 415
Lithuanian Course, 415
Living Accommodations, *See* Housing and Food Service
Loads, *See* Academic Status
Loan Programs, *See* Employment and Loan Programs

Major Program, D.Ed., 50
Major Programs, 6, 38
Management (Great Valley), 275
Management Courses
  At Behrend, 124
  At Capital, 130
  At University Park, 118
Management Information Systems Courses
  At Behrend, 125
  At University Park, 119

Man-Environment Relations, 276
Marketing Courses
  At Behrend, 125
  At Capital, 130
  At University Park, 120
Mass Communications, 278
Master of Agriculture, 54
Master of Arts, 53
Master of Business Administration, 53
Master of Education, 55
Master of Engineering, 56
Master of Environmental Pollution Control, 56
Master of Fine Arts, 57
Master of Forest Resources, 57
Master of Health Administration, 57
Master of Landscape Architecture, 57
Master of Music, 58
Master of Psychosocial Science, 58
Master of Public Administration, 58
Master of Recreation and Parks, 58
Master of Science, 53
Master's Degrees, 52
Materials Science Courses, 415
Mathematics, 282
Mathematics Education Courses, 167
Mechanical Engineering, 288
Medicaid Benefits, 27
Metals Science and Engineering, 292
Meteorology, 295
Microbiology, 298
Microbiology, Hershey, 300
Mineral Economics, 302
Mineral Engineering Courses, 416
Mineral Engineering Management, 304
Mineral Processing, 305
Mining Courses, 309
Mining Engineering, 308
Minor Field
  D.Ed., 51
  Ph.D., 50
Minority Graduate Opportunities and Faculty Development, Center for, 24
Minority Graduate Scholars Awards, 31
Minority Students, 35
Molecular and Cell Biology, 311
Motor Vehicle Regulations, 45
Music, 313
Music Education, 313

Neuroscience, 316
Nondegree Student Special, 35, 37
Nondiscrimination, Statement of, 2, 34
Nuclear Engineering, 319
Nursing, 321
Nutrition, 323
Nutrition in Public Health, *See* Nutrition

Off-Campus Credits, 47
Operations Management Courses
  At Behrend, 125
  At University Park, 120
Operations Research, 326
Oral Examination Doctorals, 49
Other Courses and Options Carrying Graduate Credit, 410
Other Members of the Graduate Faculty, 420

Parking on Campus, *See* Motor Vehicle Regulations
Part-Time Academic Status, 42
Pathology Courses, 416
Pediatrics Courses, 417
Penn State Erie, The Behrend College, 4, 17
Penn State Great Valley, 4, 18
Penn State Harrisburg, The Capital College, 4, 17
Penn State Press, 20
Pennsylvania Resident Status, 36
Petroleum and Natural Gas Courses, 330
Petroleum and Natural Gas Engineering, 330
Pharmacology, 332
Ph.D. — Additional Specific Requirements, 49
Philosophy, 334
Physical Education *See* Exercise and Sport Science
Physics, 337
Physiology, 340
Placement Center, *See* Career Development and Placement Center
Plant Pathology, 343
Plant Physiology, 346
Plant Science Courses, 417
Policy Analysis, 348
Political Science, 350
Polymer Science, 353
Portuguese Courses, 417
Postdoctoral Fellows, 36
Poultry Science, 356
Procedures and Regulations, 38
Professional Accountancy Courses (Capital), 130
Professional Degrees, 6, 38
Professional Skills Minor, 417
Program Locations, 17
Programs, 6, 38
Programs of Study, Graduate, *See* Graduate Programs and Degrees Conferred
Protection of Human Subjects, 46
Provisional Admissions, 37
Psychology, 357
Psychosocial Science, 362
Public Administration
  At Capital, 368
  At University Park, 365

Qualifications (Admission), 34
Quantiative Analysis Courses (Behrend), 125
Quantitative Business Analysis Courses (U.P.), 121

Reading, Communication, and Language Education Courses, 167
Real Estate Courses, 126
Recreation and Parks, 371
Recreational and Athletic Facilities, 24
Refund Policy, Tuition, 29
Registration, 39
  Continuity of, 39
  Continuous (Ph.D.), 50
  Near Completion of Program, 44
  Procedure, 40
  Time of, 39
Regulations, Procedures and, 38
Religious Studies Courses, 417
Research, 18
Reseach Facilities, 18
Residence Requirements
  D.Ed., 51
  Ph.D., 49
Residency (Pennsylvania), 36
Resuming Study, *See* Continuity of Registration
Ritenour Health Center, *See University Health Services*
Rural Sociology, 374
Russian Courses, 418

Sanitary Engineering, See Environmental Engineering
Schedule of Courses, 41
Scholarships, *See* Student Aid
School Psychology, 376
Science Course, 418
Science Education Courses, 169
Science, Technology, and Society Courses, 419
Second Doctoral Degree, *See* Guests of the University
Senior Student Admission, *See* Undergraduate Students
Slavic Courses, 419
Social Science Courses, 365
Social Services, Community, *See* Community Systems Planning and Development
Social Studies Education Courses, 169
Social Work Courses, 419
Sociology, 377
Solid State Science, 381
Spanish, 383
Special Education, 386
Special Interdisciplinary Majors, 38
Specialized Computing Facilities, 21
Special Nondegree Students, 35, 37
Specific Charges, 29
Speech Communication, 388
Speech Pathology and Audiology, *See* Communication Disorders
Staff Employee Credit Status, 43
Standard of Conduct, 46
Statement of Nondiscrimination, 2, 34
Statistics, 392
Student Aid, 30
Student Employment, 30, 33, 43
Student Pennsylvania Resident Status, 36
Student Services, 25

Teaching and Curriculum, 396
Teaching English as a Second Language, 398
Test of English as a Foreign Language, *See* International Students
Theatre Arts, 399
Thesis
  D.Ed., 51
  M.A., M.S., 53
  M.Ed., 56
  Ph.D., 50
  Preparation, 45
  Research, 45
Time Limitation
  Doctoral Degrees, 47
  Master's Degrees, 52
TOEFL, *See* International Students
Traineeships, 30
Training and Development, 403
Transfer Credits, 36
  Doctoral Degrees, 47
  Master's Degrees, 53
Tuition and Charges, 28
Tuition Grants-in-Aid, 31
Tuition Refund Policy, 29

Undergraduate Students, 36, 37
University Health Services, 26
University Libraries, 19
University Park Campus, 4, 18
Unsatisfactory Scholarship, 45
Urban and Regional Planning, 419

Veteran's Benefits, 33
Veterans Outreach Office, 28
Veterinary Science, 405
Visiting Classes, 41
Vocational Education, 407
Vocational Industrial Education, 408

Wildlife Courses, 216
Wildlife Management, *See* Fish and Wildlife Sciences
Women's Studies Courses, 420
Work Study Program, Graduate, 32

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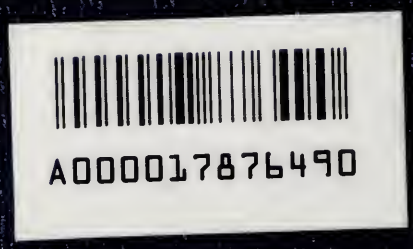
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